Operator Manual

Digital Communication
and
Measurement Receiver / Transceiver

RDR54 / 50

Version: English V 4.07
First posted: 31.10.2012
Last change: 18.11.2013

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1. Overview

The RDR54 receiver covers a frequency range from 1 kHz to 30 MHz, with signal processing of AM and FM signals detecting frequencies down to 0 Hz. An option is available to cover 50 - 54 MHz, 87.5 - 108 MHz and 144-148 MHz.

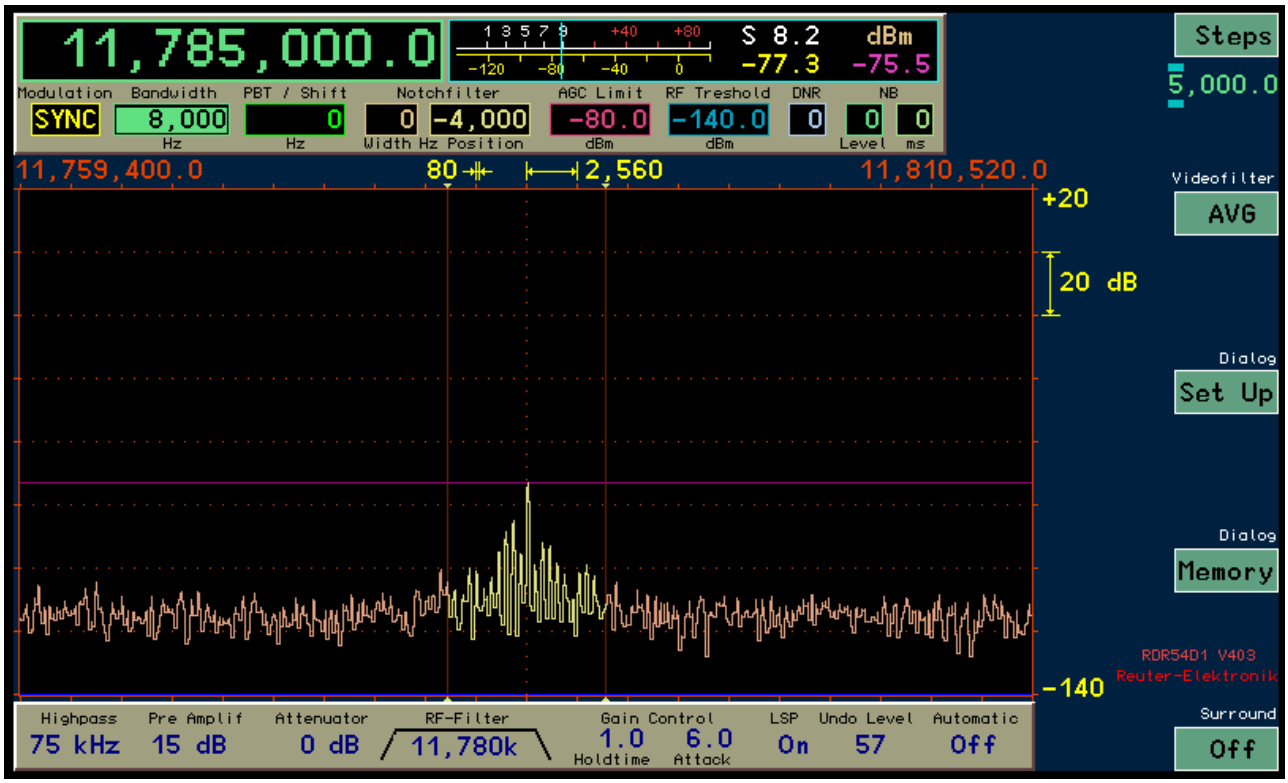
The received and demodulated signals from two independent audio channels are available via a stereo headset and / or the built-in speaker (function “communications receiver”). Signals with double sideband modulation, single sideband, with or without a carrier, keyed signals (CW, Morse radio) as well as FM signals can be received. The receiver bandwidth is adjustable within a wide range, either with a manual gain or via the configurable automatic gain control.

The RDR54 receiver is based on digital signal processing representing an enhanced Software Defined Radio (SDR) approach. The digitization of the received signal is performed without prior frequency conversion directly to the digital domain using a total bandwidth of about 150 MHz. A second conversion is done from the time domain into the frequency domain using fast proprietary algorithms (no FFT). The result is a spectrum of approximately 164 kHz width, "cut out" with a selectable frequency resolution. Additional signal processing is performed then in the frequency domain, except for FM.

The received signals are represented as a spectrum with high resolution and accuracy in an amplitude-frequency diagram (function “measurements receiver”). The resolution can be set manually as low as 2.5 Hz per column (roughly corresponding to the parameter "Residual Bandwidth RBW" in conventional spectrum analyzers). A dynamic range of approximately 140 dB between the noise floor of the unit and the maximum input voltage can be achieved. The spectrum can also be shown as a "waterfall diagram" with selectable speed.

The unit is equipped with its own power supply and is designed as a tabletop unit for indoor use. Size and weight allow easy portability. A USB 2.0 interface is provided for remote device control and data acquisition

The receiver architecture consists of a base mainframe unit with plug-in modules which are easily replaceable. All major software components are upgradeable via the USB interface, as well as all the hardware configurations used in the programmable circuits (FPGA). Connection to an Ethernet network is possible using an optional module.



RDR54 Main display window

2. Specifications

Frequency range (antenna input):	1 kHz to 30 MHz Optional 50 to 54 MHz, 87.5 to 108 MHz, 144 to 148 MHz
Tuning:	step increment 0.5 Hz to 999,999.5 Hz, direct input from the keyboard for almost all values
Frequency deviation (internal oscillator):	<± 1 ppm min after 10 min., internal manual calibration
External synchronization:	about ± 100 ppm at 0 dBm external oscillator level
Input impedance:	50 ohms, 22 µF blocking capacitor internal / 25 V-
Max. input level:	0 dBm, +20 dBm with attenuator (not for 6m)
Preamplifier (switchable):	Inverting type with 1k ohms feedback resistance and 0 ohm input resistance (idealized)
Level of accuracy:	<± 1 dB without filter, <+1 -2 dB with automatic RF-Filter
Low-pass filter (1 dB limit):	AUTOmatically tuned, MANUally selectable, 50M, 87M and 144M or OFF
High-pass filter (1 dB limit):	AUTOmatically tuned, MANUally selectable, 54M, 108M, 148M or OFF
Gain control range (manual and automatic):	140 dB in 0.5 dB steps
Hold time control:	0 ... 99.5 s in 0.5 s steps
AGC speed control:	0.1 ... 99.5 dB/s in 0.1 … 0.5 dB/s increments
Dynamic range ADC:	17 bit, at least 105 dB, intermodulation and aliasing dependent
Dynamic range of signal processing:	at least 36 bit linear, audio and dB-converted signals 18-32 bit
Resolution time-frequency conversion:	2.5 Hz ... 320 Hz in 8 steps (each doubling)
Frequency band time-frequency conversion:	163.84 kHz, 4-times over sampling
Receive channels:	2 channel audio, 1 video channel (spectrum for measurement purposes and waterfall diagram), independently adjustable frequency bands within the t / f conversion range
Demodulation audio channels:	SYNC (A3E, H3E carrier synchronous), DSB (A3E, H3E without carrier), LSB and USB (J3E), CW (A1A), narrow-band FM max. ± 5 kHz deviation, wide-band FM (see module RFM32), AM-E (AM envelope detector)
Demodulator bandwidth (= audio bandwidth):	2.5 Hz ... 20.0 kHz (5 Hz steps minimum), fixed at 5, 7, 10 or 14 kHz for FM-N and AM-E
DNR Noise reduction system:	2 algorithms: IQ process: Stage 1 - 9 (19), magnitude method: Level 10 (20) - 19 (39). Values in brackets for double-sideband demodulators.
NB Noise Blanker:	Adjustable response threshold (16 levels) and blanking time (0 - 99 ms)

Speaker channel:	PWM ("Class D"), 10 Vpp level Ri = 0.2 ohms, 13 - 18 bit resolution, internal filter, maximum power 2 W
Headphone channels:	2 independent, stereo, 24-bit DAC, max. 13 mW at 16 ohms
Spectral resolution x-axis (frequency):	640 columns / 20 scale units, resolution of 2.5 Hz ... 320 Hz / col in 8 steps (each doubling)
Spectral resolution y-axis (level):	320 lines / 8 scale units, 0.05 ... 0.5 dB / line (2 ... 20 dB / scale unit) in 4 steps, dBµV or dBm scale, 2 markers, S-level display with 0.1 S resolution, y-position adjustable max. 240 dB
Video spectral filters:	Off, arithmetic average, quasi-peak, maximum hold at 0 ... 9.9 s or infinite measurement time (automatic reset to 0 at the end of the manually set measurement time)
Frame rate (spectra / s):	4 times the frequency resolution, max. 57.14 frames per second
Waterfall speed:	8.75 / 17.5 / 35 ms / line (0.35 / 0.7 / 1.4 s / scale unit)
Color levels for level scaling waterfall:	16 (2 colors per scale unit of y-axis of the spectrum)
Memories:	63 for Undo, 63 free programmable, memory position “0” reserved for the factory setting / bootloader
Display (WVGA):	TFT 5.0 inch (12.7 cm) diagonal, 800 x 480 pixels, 256 colors, max brightness 350 cd / m², viewing angle (horizontal / vertical) 90 ° / 70 °, contrast (black / white) 250, reaction time 35 ms
SMB connectors (male):	ANT1 (1 kHz ... 30 MHz), ANT2 (50 ... 54 MHz), IN1 (0.1 kHz... 150 MHz -3 dB without aliasing filter), CLK (external oscillator 83.88608 MHz with 0 dBm)
Other connections:	3.5 mm stereo headphone jack, 3.5 mm jack S / PDIF (digital audio, only special versions), Mini-USB 2.0 Type B, high-speed 480 Mbps
Power supply:	110 / 230 V Class I, <25 VA, <1 VA standby
Size (width / height / depth):	290 mm / 125 mm (folded up feet) / 245 mm
Weight:	max. about 5 kg, depending on the version / equipment
Environmental conditions:	0 ... +50 ° C or 32 ... 125F ambient temperature <= 90% rel. humidity non-condensing, indoor use pollution class 2
Compliance:	CE according to DIN EN 55013, EN 55020, EN 60065 (Consumer electronics and related equipment), RoHS / WEEE Directive, ear-Reg. 27676700

3. Safety precautions

Please always note the following safety precautions!

The device is intended for use at 110 V or 230 V AC mains voltage. Make the connection using the provided or an equivalent AC cable with ground pin to a properly grounded socket! Damaged cables must be replaced immediately, damaged sockets should not be used!

Carefully check the voltages of the power supply! Connect the equipment into an outlet only with fuse protection of 16 amps or less! Voltage, frequency and power consumption of the device are labelled on the back near the power connector.

Disconnect (pull plug) electric power, in case you want to remove screws or would like to open the receiver! The unit contains no user-serviceable components for replacement (eg. bulbs or fuses).

The device is intended for indoor use. Avoid excessive moisture, never put liquid filled containers on top of the unit! If you accidentally put moisture (such as spilled beverages) into the device, pull the power plug from the socket immediately and send the unit back to check on the supplier!

Check the recommended temperature range before using the equipment! Don't switch the unit "on" when temperature is above or below the recommended range! The device has a fan on the back near the power connector for dissipating heat. Do never obstruct the fan opening (for example, by using the device on towels or newspapers) and set it always so that there are at least 10 cm (4 inches) between the rear panel and other items! Do not place open flames such as candles right next to the device!

Always provide a safe placement on a flat, straight and solid base of sufficient carrying capacity! Transport the device only in either solid boxes or crates (for example the shipping container), or transport it by firmly grasping the sides with both hands! The unit can cause an injury in case of a drop under its own weight!

Do not expose this equipment to mechanical stress caused by impact, pressure, vibration or shock which exceed that commonly used in the home with the use of electronic devices! The control elements and specifically the front window of the display are very sensitive to pressure or impact. Never press a control with a force beyond the extent necessary and do not press on the display (except display with touch screen)!

If you notice any damage to the device, disconnect it (pull the AC plug) and stop the operation immediately! Send it in for repair to the supplier if necessary.

Would you like to dispose the device due to damage or no more usability, send it back to the supplier or return it to your local waste collection center. Dispose of the appliance elsewhere, such as households, pollutes our environment!

Use for cleaning of the equipment only soft, lint-free and dry cloth! Be especially carefully in cleaning the front screen of the display, because this is easily scratched. Do not use aggressive solvents, but at most a slight moistening swab with distilled water or a damp piece of cloth or microfiber! Make sure that no moisture goes into the device!

4. Device description

4.1 Mechanics

The RDR54 consists of a system enclosure and discrete modules. The RDR54 uses a main frame masterboard with slots for the function modules. All components are electrically connected through the backplane.

The enclosure itself is made of two machined aluminium side walls and a bottom and lid made of extruded aluminium. These four parts are held together by a total of 16 M3 Torx-head screws. The backplane is inserted into corresponding slots milled out of the side walls and receptacles in the floor / cover profile.

The modules (also called plug-in cards) are inserted either from the front or the rear of the enclosure. The RDR54 uses modules in two different lengths: short modules for the front panel and longer ones for the rear back panel. The modules' connectors are inserted into corresponding sockets of the backplane. They are secured by screwing them into the base plate of the housing. For that purpose the bottom plate has inserted threaded hole strips on front and rear. The modules are not screwed to the lid , but simply inserted into a corresponding groove of the top.

After loosing the side screws the top plate may be lifted so that access to the modules is possible: Modules can be removed after loosening the bottom plate screws.

The RDR54 contains no user serviceable parts. Changing modules is not planned as such. The device contains a self-resetting fuse which in case of an eventual failure must not be exchanged by the user.

The built-in RDR54 modules are described in the section "Operation". Unused slots are covered with a blank plate. The rear panel shows the vendor and device labels, please do not remove the labels.

4.2 Electronics

The modules are interconnected by the serial bus system. Here, the data exchange takes place under the direction of a proprietary operating system (RMF22). It recognizes the existing modules and organizes the data exchange in such a way that each module can communicate correctly, no matter to which slot on the backplane it is plugged in. The operating system provides the functionality of the modules on a higher command level to all other modules (eg. keyboard functionality or graphic commands). The RDR25 module (or software task installed on the module) is responsible for the basic functionality of the equipment (as “master”). In the RDR54 this is the signal processing card RDR25 from firmware version “C” on.

Three bus systems connect the modules to handle the data exchange:

- JTAG bus for test purposes and for the basic programming of the device (only at the manufacturer)
- LVDS bus for distribution of the ADC data to all slots
- UART bus for exchange of operating system commands.

The LVDS bus system is used (in addition to the signal-generating ADC module RAD17) in the RDR54 only by the signal processing board RDR25.

There is a special connection between the signal processing board RDR25 to the graphics card FGC1 and the speaker module FDA20. Through this connection (LVDS level, proprietary protocol), high-speed data is transferred (about 84 MBit / s), which enables a high frame rate on the screen and a high possible audio frequency for the output signal.

4.3 Firmware

With the exception of the signal processing board RDR25, all modules are running standard software which provides the functionality of the plug-in modules as slave units. These modules have nothing to do with the basic device functionality, they only carry out commands or generate / process the same data sets (eg. graphics commands for the generation of characters for text or graphics on the display). The modules can provide their functionality for various types of equipment and utilities, for example in a measuring application as an oscilloscope or signal generator.

The actual device function as well as the entire user interface is provided by the software of the signal processing board RDR25. It also processes the data from the ADC module RAD17, the processed data is then sent to the video card FGC1 and audio card FDA20.

To perform these functions on the card, a highly integrated FPGA (field programmable gate array) is provided which is programmed as a SOC "system on a chip". Here all the necessary components are modelled in software (as so-called "soft cores" or "IPs" = Intellectual Properties). The following modules are installed in the FPGA RDR25 card:

- 32 bit CPU with program and data storage and data interfaces
- Digital Down-Converter to cut out the main reception area of the ADC data stream
- Time-frequency converter to generate the spectrograms
- Data acquisition board of the video channel for the selection of spectral lines to be displayed and the calculation of the logarithmic magnitude (dB scale)
- Data acquisition module of the audio channels to choose the audible content and to make spectral and level scaling (gain adjustment or automatic gain control)
- Quad-data rate memory interface for controlling a QDR-SRAM with two 36-bit data buses
- High-speed serial LVDS interfaces for data transmission to graphics card and speaker module.

The functionality of the FPGA and thus the entire device is stored as a “configuration". Several such configurations can be transferred from the PC via a boot loader program and can be activated later. A configuration remains active (even after turning off and on again) until selection of another one or an error occurs.

The following description applies to configurations from firmware version 300 on. For older versions (V1xx or V2xx) please refer to the appropriate manuals.

5. Operation

5.1 Controls and connectors

The RDR54 receiver has the following operating and connection options (pictures can vary slightly).

230V ~ 50 Hz mains voltage

Connect the AC cable here.

PC-connection

Connect the RDR54 to the PC / Laptop using a USB cable (mini-USB Type B).

RF terminals

-

Connect antennae or test leads according to the frequency range.

Keyboard

The operator controls the receiver by pressing the buttons and press / turning the main knob. The buttons are illuminated with LEDs.

The button "ON / OFF" is used to turn the device on and off. As soon as the power supply is connected, the status LED on the button ON/OFF turns red, indicating that the device is in standby mode. When switched ON the LED turns to yellow. In case of an internal fault, the device switches off automatically, but the status LED will still be yellow. To restore power, first switch to stand by (status LED “red”) then try to switch ON again. In case the device turns itself off several times, pull the mains plug and send it in for repair.

In case you would like to avoid the low power consumption of the device in standby mode, connect the power cord into an electrical outlet that can be switched off (eg. power strip). All settings are buffered and protected against power loss.

The number buttons are used to enter decimal values, e.g. frequencies. Pressing a button other than "0" starts the input mode. During a decimal input, the LEDs of the number keys are lit. Close the input mode with "F1" (escape = discard the input) or “F4” / "F5" (OK = confirm entry) button. F4 allows the direct entry of a kHz value, F5 allows a direct input of a MHz value. Example: “1422” and “F4” will set the receiver directly to 1422 kHz. “15” and F5 will set the receiver to 15MHz or 15000kHz respectively.

The "F1" to "F5" function keys have different functions ("soft keys"), depending of the operating mode of the RDR54. Their momentary function is shown in the display. There is a basic function and a special function. The special functions are indicated by the corresponding LEDs being lit. In case a function requires a specific key operation to be completed, the required key is lit by LED, e.g. in order to tune in to a specific frequency, the confirm key “F5” is mandatory to complete the operation.

The main knob is used for continuous indexing of values. It features an audible and tactile feedback (the special version with a magnetic encoder clicks inaudible). Each detent leads to an increase (clockwise) or decrease (anti-clockwise) of the current adjustment which will be displayed on the screen. The adjustment knob can also be pressed and then be rotated while being pressed. We will refer to this operation from now on as PRESS&SELECT. With the knob being pressed you can shift from input tag to input tag, say from demodulator to bandwidth choice. In order to change a value, let the knob go and now change the setting at will.

The setting of the active entry point can also be done by turning the main knob in the unpressed state: short press / release à value will flash à turn à stop at the desired location à quick press / release.

The active input marker consists of a color-inverted representation of the value. In the main screen while selected the text or numeric value is shown in its window in a dark color on a light background, in contrast to the usual representation of the non-selected values with light colored lettering on a dark background.

Example:

The entry window for "Bandwidth" is now selected, the entry window for "Modulation" is inactive.**Speakers and**

Headphones

Built-in speaker and connections for stereo headphones and microphone

By turning the knob, the speaker volume is increased (clockwise) or decreased (anti-clockwise). The button has a detent and no stop. The volume cannot be reduced below zero or increased above the maximum value even with further rotation of the knob. The knob can be pressed and rotated, in this case only volume of the headphones will change.

The socket for the headphones (KH) is a 3.5mm or 1/8 inch jack for stereo headphones with standard wiring. All standard headphones with 16 ohms impedance or above can be connected.

The loudspeaker (LS) can be completely disabled by a software setting (see dialog "Setup"). In this case, the volume control of the headphones is controlled directly with a rotation of the knob. Pressing the knob is not needed in this case.

For the use of the RDR54 as a transceiver (“transmit mode”), a microphone socket (MIK, RJ-45, 8-pin) is provided. Their circuitry and use are described in the section "transmitter module RPA5".

Display

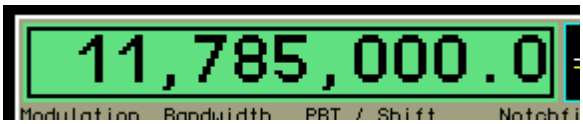
The display is used to display values, the spectrum of signals and the device status.

The display has WVGA resolution of 800 x 480 pixels. It can display 256 colors and has a non-reflective screen. The brightness can be adjusted in the Setup dialog.

All operations of the RDR54 (with the exception of the volume setting) are controlled through the selection and modification of the displayed graphic and numeric values. A screenshot is shown on page 4 of the Chapter “introduction”. What follow is the explanation of all settings and indicators.

5.2 Receiving frequency

All frequencies are displayed in the SI unit Hz (Hertz), kHz etc. and are separated with the usual colon and dot for the decimal point. The image shows 11,785,000 Hz or 11,785kHz.



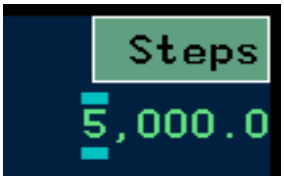
Press and rotate the knob until the color of the frequency window is displayed in reverse color (as shown above). With the frequency window selected this way each increment of the rotary knob changes the frequency by the value of the set step size. A direct input via the numeric keypad is also possible (always begin with digit different from "0"!). Special functions are available using the function keys: the decimal dot and the deletion of the last digit and the acceptance or rejection of the input.

The display of the frequency itself has a special function: in case your signal exceeds the maximum input level of the ADC, color of the window (not selected as input set) or the number itself (selected) will turn RED. In this case, you have to turn on then the attenuator (see dialog "Setup") and / or decrease the input voltage to the device input!

Settings can be made with an accuracy of 0.5 Hz. There are different setting limits, depending on the selected filters (see description in "Setup dialog"). Direct entries are rounded to the possible maximum or minimum value. Rotation of the knob at the region boundaries has no effect.

5.3 Tuning

The step-size for the receiving frequency can be adjusted, can be changed by pressing the "F1" key. Then the step size display shown below is active as an input window. This is also indicated with the LED of the “F1” button being lit.



Step-size selection

Now you can change the step size by rotating the knob. The value changes only from a “lowest” digit upwards. It is characterized by two horizontal bars above and below the selected digit. These bars (and thus the least significant input digit) can be moved sideways by pressing and rotating the knob. In our example, 5000 Hz is the selected step increment.

Return to the frequency as the active setting by press "F1" (or "ESC" = Escape). From now on, the frequency increment when turning the tuning knob is the selected value of the step size (here: 5000 Hz or 5 kHz).

A fast adjustment of the step size is possible if the value contains only one digit (eg. 1,000.0 = 1 kHz): at the desired position of the bars (in this example the thousands digit) press the desired number button (in the example "1"). The full value including all zeros will be used immediately and finishes the steps adjustment, a confirmation with "F1" is not necessary. This way you can quickly switch between standard increments eg. 1 kHz, 5 kHz and 9kHz by simply pressing “F1” followed by the desired number. In short: the key sequence “F1”, “5” will set the step size to 5 kHz (if the cursor was positioned at the thousands digit).

Special function of the key "0"

The adjustment of frequencies and the corresponding steps can cause slightly offset settings. In this case an improvement can be reached by pressing the "0" to remove the offset as follows:

- Frequency values are always set to the nearest lower integer multiples of the corresponding step size, unless a range limitation is set or a hold function is active.

- When adjusting the step size, all digits right from the selection bar are set to zero or it will be set to the lowest or highest possible value of the increment.

This feature allows you to easily correct frequency values after changing the step size or automatically adjust to the field boundaries.

Example (the "Hz" is not displayed):

Current frequency setting 1,124,550.0 (Hz), the corresponding current step size is set to 10.0 (Hz).

à Adjustment of the step size (by pressing "F1") to 1,000.0 (Hz). If you now change the frequency using the tuning knob it will be adjusted in 1000 Hz steps, say with clockwise rotation: 1,125,550.0 ... 1,126,550.0 ... 1,127,550.0 and so on.

Your intention in choosing the new step size was probably the desire for tuning the frequency to exact multiples of the "kHz frequencies". Normally, you had to set such a "straight" frequency by direct input or by choosing a new step size which is already set. Alternatively you would have to change the step size first back to 10 Hz (50 Hz, 150 Hz or 450 Hz would be more effective) to adjust and "smooth" the frequency and then switch back again to the 1,000.0 step size.

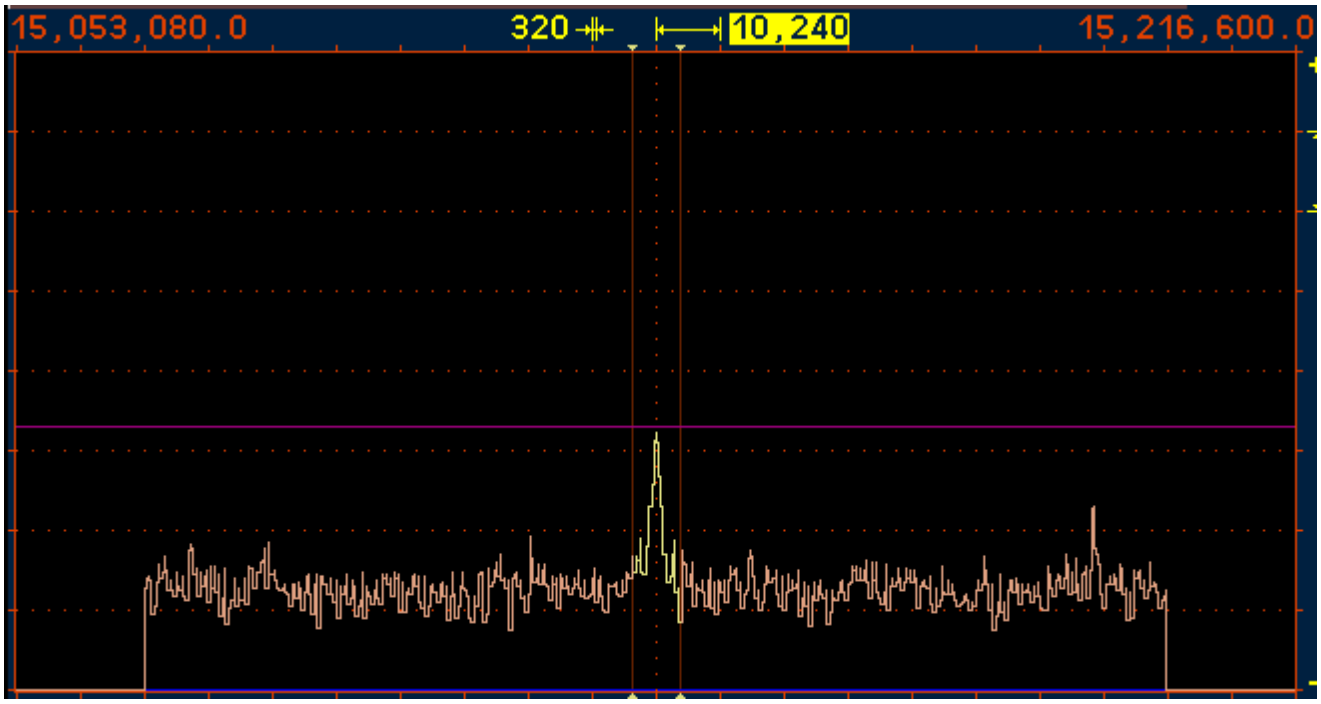
This effort can be avoided by simply pressing "0" after the adjustment of the step size to 1,000.0 (Hz). The frequency is now automatically set to the next lower multiple of 1000 Hz, eg. 1,124,000.0 (Hz).

Similarly, the selection of a given step size can be simplified (“F1” is lit). Press and turn the tuning knob shifts the bars to the left until on or before the first digit > 0 and then turn the knob for a plurality of detent steps to the left without pressing the tuning knob.

The increment is quickly adjusted to its smallest value "0.5". Now you can re-approach the point that corresponds to the desired value (keep the tuning button pressed!), for example to the thousands digit. After choosing the step size (but before finishing the setting using “F1”), Press the "0" key. This also sets the 0.5 Hz digit to 0.

5.4 Bandwidth

The main display on the screen is the representation of the spectrum ("Spectrogram") of the received signals within a user selectable frequency range. The RDR54 transfers a 163.84 kHz wide frequency band from the time domain into the frequency domain thus generating the spectra.



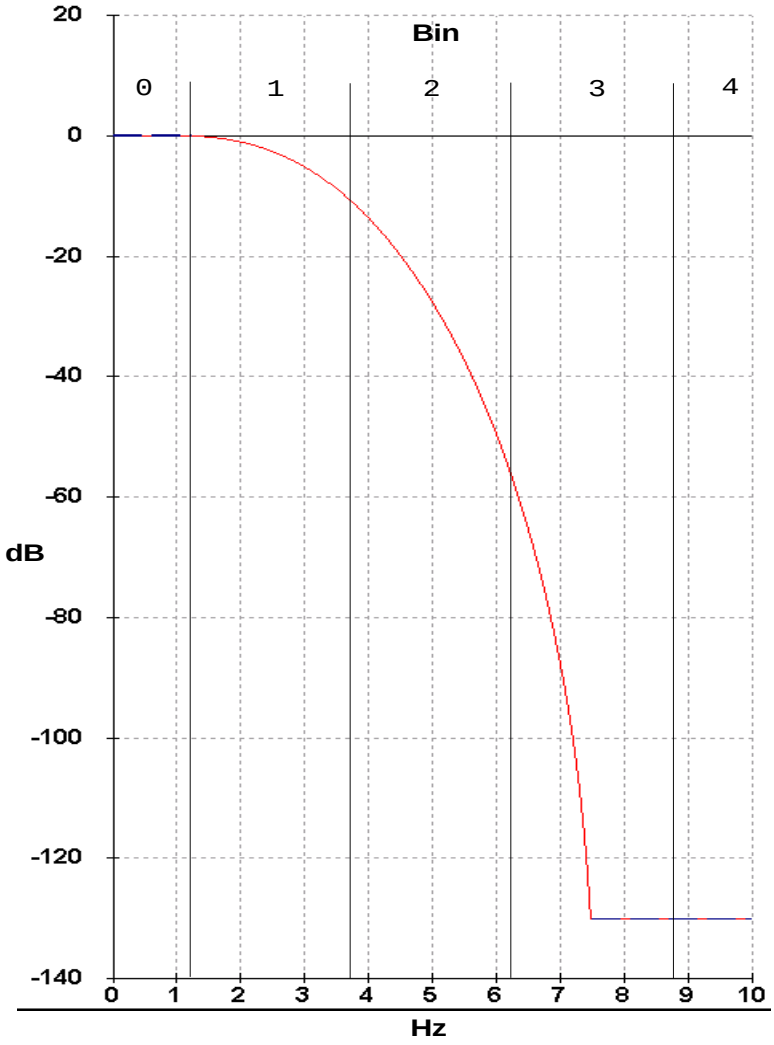
The adjustment of the displayed width of the spectrum is done by selecting the width of the horizontal display unit, in the example above the value of 10,240 (Hz). On the left the width of a spectral line (1 pixel on the screen) will be displayed, 320 in our case. The width of spectral lines corresponds to the distance from another and is equal to the frequency resolution.

On the WVGA display 20 sub-units of each 32 lines (pixels) are available. Accordingly, this represents the overall width of the display. The frequencies of the first and last line are shown on the top left and right of the spectrogram. Please note that the counting starts at 0 (the first line to the left) and goes up to 639 (last line on the right). The receiving frequency is always at the center of the spectrogram (except with demodulator “EUSB”).

The maximum visible width can be zoomed to the width of the main reception area (see picture above). In this case the frequencies represent the left and the right side of the spectrum (only 512 lines wide). Any reduction in the width range is done by bisecting the current width. The minimum width is given by the minimum possible width of the spectral lines (= highest possible resolution) of 2.5 Hz (RDR50 only 5 Hz).

Within a spectral line, the amplitude attenuation is less than 0.2 dB. The line width of -0.2 dB corresponds to the distance between the vertical display lines. If a signal is exactly “between” 2 lines, it is shown as two lines of equal size and with a maximum of 0.2 dB attenuation. There is virtually no "picket fence effect" or similar artefacts commonly found at spectra generated by Fourier transforms.

Outside of a spectral line, the attenuation increases rapidly and reaches 130 dB at the third line left and right from the selected frequency. This attenuation is maintained across all lines, there are no spurious resonances ("leakage") or similar artefacts of the Fourier transform.



Filter curve of a spectral line width of 2.5 Hz

The lines of the graph of the spectrogram are always drawn so that its visible height exactly equals the value of the corresponding spectral component. There are no oblique lines drawn (intermediate values with undefined "interpolated" level).

The frame rate of the spectrogram is directly dependent of the selected resolution. The RDR54 calculates the spectra using a time sequence corresponding to 4 times the frequency resolution (4x over sampling). There is no frame rate limitation related to the resolution by principle (as Fourier transform has), just hardware speed and memory size limits the achievable over sampling factor.

Example:

Resolution 5 (Hz) = 160 Hz / sub-unit à spectrum display frame rate = 20 Hz (images / s = framerate). When switching to 2.5 Hz “only” 10 frames / s are displayed, when switching to 20 Hz it is 40 frames / s. The maximum possible frame rate is equal to the frame rate of the display (58 frames / s). Higher transformation rates of the spectrum are not limited internally (up to 1280 spectra / s) but used for further processing (audio generation or retention of maximum values) for example.

The maximum spectral width of 163.84 kHz is the constant time-frequency transformed bandwidth of the RDR54 receiver. All further signal processing (except for FM and AM-wideband envelope demodulation) is done within this range. The width of the audible bandwidth inside this spectrum is determined by setting the demodulation filter bandwidth.

Audio bandwidth window

In the spectrogram two small vertical lines indicate the limits of the audible range. Signals within this section are shown in light yellow, inaudible signals outside the selected range are shown in light red.

The position of the bandwidth can be shifted from the symmetrical position to the receiving frequency by the setting value "PBT / Shift" (also known as “Passband Tuning”).

Value of the passband shift

Bandwidth and Shift can be adjusted in increments which are dependent on the respective demodulator. In the demodulators "Auto" to "CW" step size can be set from 20 Hz up to a bandwidth of 10 kHz, with larger bandwidths 40 Hz. Note, in double-sideband demodulators the increments are applied to both sides. Bandwidth can be adjusted down to almost twice the minimum possible spectral line (5 Hz at RDR50) and up to about 20 kHz (double-sideband AM).

The "filter edge" of the audible range and the attenuation of the non-audible range correspond to the values of the spectral lines used. They can be read from the diagram above by multiplying the values by 8 (20 Hz audible resolution) and 16 (40 Hz). At bandwidths below 40 Hz in each case the values of the next lower level, ie at 5 Hz bandwidth (absolute minimum) the audible filter response is the original 2.5 Hz line shown above.

In the other demodulators, there are fixed bandwidths (generally 4 selections: 5 kHz, 7 kHz, 10 kHz and 14 kHz). In these demodulators frequency shift is not possible (value is always set to 0). Slope and attenuation of the filters are generally lower than the spectrum-based demodulators.

For FM-W selectivity-optimized versions exist with a steep edge filter and distortion-optimized versions by Bessel functions, ie, with relatively flat and "round" filter curve. The filters with a steep edge are referred to as "S", they should be used mainly for mono reception. The filters for high-quality stereo are our "HQ" versions. The following filters exist in software version 300 (may vary in further versions, "k" in the name stands for "kHz"):

- 50k S
- 50k HQ
- 80k S
- 80k HQ
- 120k S
- 120k HQ
- 240k S
- 240k HQ

The effect of various filters on the signal quality can be determined by using the test generator (see "Special Features" with sample diagrams).

5.5 Demodulators

The type of acoustic playback of the received signal ("mode") is determined by the demodulators. They produce sound from the spectra of the received signal ("Auto" to "CW"), or from the signal itself (all other demodulators). The audible signal corresponds to the desired modulation type.

The demodulators can be chosen by toggling in the Modulation window.

- SYNC: Automatic detection of an amplitude-modulated double-sideband signal with carrier (A3E, AM radio stations).
  The demodulator continuously determines the spectral line with the highest level within the audible range and interprets it as a carrier. The associated frequency is defined as the carrier frequency of the entire signal within the passband display; all other signals are viewed as sidebands and processed accordingly. Once a carrier is detected it is approximately 1 second "held", even if other signals reach temporarily higher values. Carrier frequency changes will be immediately "rejected" and resynchronized.

- DSB: Double sideband signal with no carrier evaluation (A3E).
  The channel processes all signals such as the carrier would be exactly on the center line of the spectrogram and generates the audio signals corresponding to the distance and level of the spectral lines

from the center line.

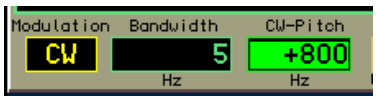
- LSB: "Lower Side Band", lower sideband of a SSB signal (J3E):
  The demodulator generates audio signals corresponding to the distance and level of the spectral lines from the center of the spectrogram to the left boundary line of the bandwidth.

- USB: "Upper Side Band", upper sideband of a SSB signal (J3E):
  The demodulator generates audio signals corresponding to the distance and level of the spectral lines from the center of the spectrogram to the right boundary line of the bandwidth.

- EUSB: "Enhanced Upper Side Band", true image or upper sideband of a very low frequency signal:
  The demodulator generates audio signals corresponding to the distance and level of the spectral lines from the most left line (may be 0 Hz) of the spectrogram to the right boundary line of the bandwidth.

- SBCW: "Single Side Band + CW", automatic selection of the sidebands at 10 MHz:
  The demodulator generates audio signals corresponding to the distance and level of the spectral lines from the center of the spectrogram to the left (receive frequency below 10 MHz) or to the right (receive frequency greater than or equal to 10 MHz) boundary line of the bandwidth. At the same time when operating as a SSB-transmitter (with expansion module) the emission of a keyed CW signal within the sideband is possible.

- CW: "Continuous Wave" Morse (A1A):
  The demodulator produces an audio tone with the level of the spectral line directly on the center line of the spectrogram and an adjustable value of the "Shift" ("CW-Pitch") frequency.



For CW, the window changes from "PBT / Shift" to "CW-Pitch."

Note: Depending of the modulation type "SYNC" to "CW", only bandwidth and shift can be changed, as the selected sideband position allows. For example at LSB, no adjustment is possible so that signals could be heard right from the center line of the spectrogram.

- FM-N: Narrow Frequency Modulation (F3E):
  The audio is generated directly from the signal of the ADC with a maximum bandwidth of 14 kHz.
  Suitable for FM signals with a deviation up to ±5 kHz.

- FM-W: Wide Frequency Modulation, with optional stereo multiplex decoder (F3H):
  The audio is generated directly from the signal of the ADC with a maximum bandwidth of 300 kHz.
  Suitable for FM signals with a deviation up to ±75 kHz. In this demodulator a stereo decoder for FM radio signals can be activated by pressing “F5”.

Note: The stereo decoder generates the left and right audio channel from the spectrum of the demodulated FM (MPX) signal. Therefore, in stereo no view of the RF signal in the spectrogram is possible. Instead, the MPX signal is presented in the spectrogram. In order to view the FM modulated RF signal, switch off stereo.

- IFIQ: Direct output of the received signal to an intermediate frequency:
  The signal from the ADC is frequency-shifted and output as a complex signal (I and Q channel) on the headphone jack. The bandwidth is approximately ±14 kHz around a 10.24 kHz intermediate frequency.

- BAlQ: Direct output of the received signal in baseband:
  The signal from the ADC is down converted and output as a complex signal (I and Q channel) on the headphone output. The bandwidth is approximately ±14 kHz with 0 Hz intermediate frequency (baseband).

Note: These two demodulators allow the output of a signal for further processing, eg by means of sound card / PC. The two stereo channels are used to represent the in-phase and quadrature signal of the complex signal output. The purpose is to enable further demodulation, such as DRM.

- AM-E: Double-sideband AM with carrier (A3E), envelope detection:
  The demodulator generates audio directly from the signal from the ADC whose amplitude response is the shape of the envelope (peak amplitude, magnitude). It does not work spectrum-based on discrete frequencies (such as "SYNC") and allows for a good reception and excellent sound with low distortion in the case of strong and stable signals. Please note that the selectivity is much reduced

compared to the other AM-demodulators.

Depending on the selected demodulator various other settings such as bandwidth and shift are saved and restored when switching the demodulator~~. In order to change the demodulator every time other values have to be adjusted.~~

Example: SYNC bandwidth shall be 6 kHz, DSB, LSB and USB only 3 kHz. Without the storage of this settings related to the demodulator the same value is present every time. One would have to adjust the bandwidth at every switch from SYNC to SSB and back again.

The automatic settings storage is not for each demodulator, but in 4 groups of demodulators:

1~~A~~.: SYNC
2.: DSB, LSB, USB, EUSB, SBCW, CW
3.: FM-N, IFIQ, BAIQ, AM-E
4.: FM-W

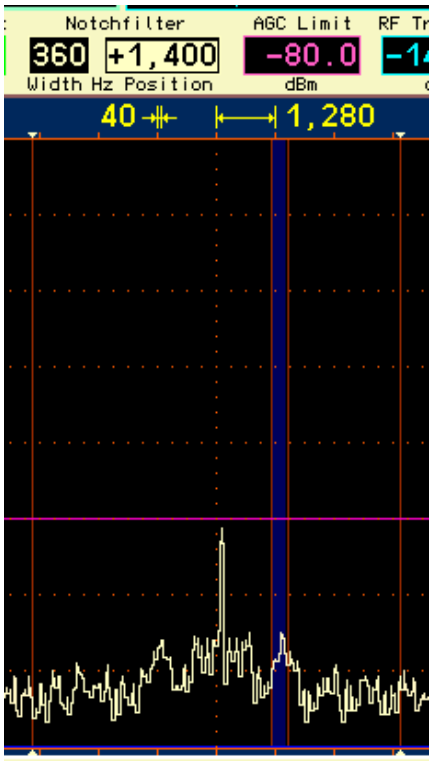
For the notch filter (see below) there is a demodulator-dependent storage as follows:

1~~A~~. SYNC, DSB, CW
2.: LSB, SBCW when frequency <10 MHz
3.: USB, EUSB, SBCW if frequency >= 10 MHz

All other demodulators do not support a notch filter.

5.6 Notchfilter

The notch filter is used to filter-out one narrow band signal within the passband for the suppression of interfering signals. The width of the filter and its position can be adjusted relative to the receive frequency. The notched-out frequency range is shown as blue color column in the spectrum.



Settings and display of the notch filter.

The relative position is converted into the absolute frequency in the passband and then stored. It remains when adjusting the receiver frequency, even if the filter area (relative position) falls outside the passband. In this case the setting of the position is limited to the maximum positive or negative value corresponding to the bandwidth. Due to storage of the absolute frequency, the setting can be automatically restored if the receiver is tuned so that the notch filter falls in the audible range again ("semi automatic" filter, tracking of relative position).

Only when the position is changed manually, the absolute frequency is newly calculated and stored.

The filter has the same damping characteristics as the bandwidth: within three 20(40)-Hz spectral lines it reaches an attenuation of more than 130 dB. At a setting of the filter width of 120 (240) Hz or wider a signal is almost completely suppressed in the middle of the notch filter.

5.7 Level scaling and gain adjustment

The level scaling of the spectrum is displayed on the right side of the spectrum diagram.

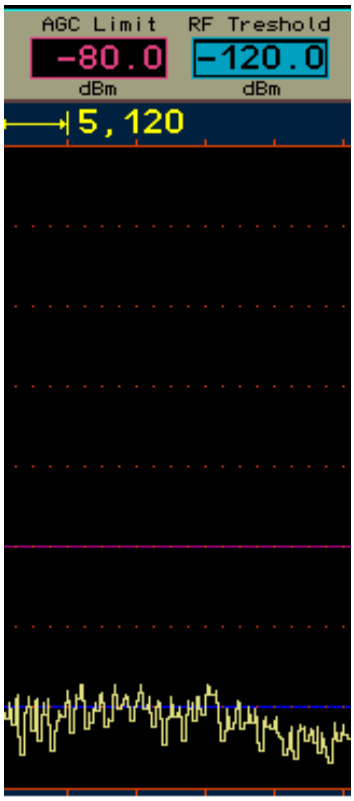
Display / set the value for the upper limit of the spectrum (in dBm, here +20dBm).

Display / set the scale per sub-unit, resolution is always 40 lines (pixel) per sub-unit.

Display of the lower limit of the spectrum and the level measurement unit.

The vertical position of the spectrum can be changed by selecting and changing the value for the upper limit and the value of the resolution for the scaling per sub-unit. The unit of measurements can be switched in the Setup dialog between dBm and dBµV.

In the spectrogram two horizontal marker windows are displayed. Their content refers the values of the "RF Gain" (manual gain control) or "AGC Limit" (automatic gain control), and "RF Threshold".



Setting and display of the lowest and highest audible level.

The lower marker (blue) indicates the signal threshold above which a signal is audible. All signals whose level is less are inaudible.

The upper marker (purple) indicates the signal level that produces the maximum level of the audio signal. Signals above this marker are limited (or distorted). Internally, the RDR54 works with a 6 dB safety margin ("headroom"), so that in case of low clipping distortion does not occur immediately.

The marker can be moved by selecting its value. Direct input using the numeric keypad is also possible.

Since the upper marker can be seen as the RF gain of the receiver (compared to analog receivers), it can be adjusted by manual operation, or as an Automatic Gain Control threshold. The mode is selectable in the Setup dialog. In automatic mode, the hold time used to set the marker position lower and the speed of the marker shifting downwards after the holding time (compares to "Decay" in an analog receiver) can be varied within wide limits. The movement upwards (= "Attack" / "Desensitization") always happens immediately upon detection of a higher level and the associated signals are processed only after the shift. The automatic mode thus prevents clipping.

Attention! The automatic control responds only to signals which are inside the passband (yellow lines in the spectrum)! Signals shown in red, (that is outside the passband or within the notch filter) will not affect the marker position. However, since these signals are not processed, they can not cause clipping.

When manual control is selected the top marker describes how by many dBs a received signal on the marker line has to be amplified to reach 0 dB (full scale) of the audio signal. This "0 dB" audio level relation to the 0 dBm RF level, is not an absolute value in dBm or dBµV because the audio signal is not generated in a well-defined impedance environment and is far more than 1 mW (0 dB audio = about 5 Vpp at headphone and 10 Vpp at speaker output). The gain value of the upper marker is to be considered a relative value.

In automatic mode, this marker is moved by the RDR54 itself. It automates the process of gain regulation. As a result, the AGC level is closely monitored and provides usable adjustments of the control parameters. The setting for the upper marker is a control limit (maximum gain) to prevent excessive gain. This limit can be set directly in dBm / dBµV as it relates to the received signal. It is a useful control to limit excessive gain chasing a signal into noise which results in listener audio noise fatigue.

When using the FM demodulators, the markers work differently:

- FM-N: The signal for the narrow FM demodulator is used under the following scheme:

The lower marker receives the sum of all the audible signal spectral lines. It must be positioned above the visible signal spectra lines for its function. The upper marker determines gain / control limit. However, since FM is an amplitude suppression modulation scheme, the gain is not critical to the demodulation process. Only when there is too little gain (near the top marker, signal is very small) will the demodulation be aborted. The top marker can thus be used as a "noise gate" or "squelch". Set it so that unmodulated noise is not demodulated and the demodulation starts only at useful signals.

- FM-W: The signal for the wide FM demodulator is used prior to gain regulation.

The FM-W demodulator has a special algorithm for very high amplitude suppression and therefore requires no gain regulation. The lower marker can be used for a "mute" function.

In stereo mode, the MPX signal is used for spectrum generation. Now the upper marker has again the function of the gain control / regulation. But only for the decoded left and right audio channels, not for the RF or the MPX signal. For more information look on the description of the extended FM advertisements.

5.8 Noise reduction DNR

"DNR" stands for "Dynamic Noise Reduction", the noise reduction system of the RDR54.

A setting other than zero sets various algorithms with different levels of efficiency in operation. Basically, the effect of the DNR setting is programmed so that each decade (10-place of the setting) calls a different algorithm or a combination of multiple algorithms; within each decade the effect is 10 – 100% adjustable. For the type and number (max. 10) of the programmed algorithms, refer to the technical data.

Attention! The setting of the noise reduction system has a major impact on audio quality! In addition to the planned reduction of noise the quality of usable signals is also affected. Set the noise reduction system only

when needed to values greater than 0 and find an experimental setting that comes closest to your needs.

5.9 Noise blanker NB

In addition to the dynamic noise reduction system "DNR" the "NB" (Noise Blanker) is available for impulse noise reduction. This system recognizes signal glitches (eg, discharge, ignition interferences, voltage spikes caused by switching, ...) by their typical fast signal rise and their broadband frequency spectra respond.

The noise blanker benefits from the spectrum-based operation of RDR54. The signal processing is performed in the entire spectral range of around 164 kHz width, which is separately examined in eight broad areas of about 20 kHz slices. The recognition is always in the region with the lowest signal level to avoid being influenced and overlapped by strong useful signals.

If a glitch is detected, instead of the desired data signal, a special identification signal is forwarded to the audio module (FDA20). This adds a replacement signal instead of the glitch in the generation of audio for speakers and headphones. There is no processing to decrease or mute the original (faulty) signals.

A replacement signal which is inserted in place of the faulty original signal can be calculated, because at the time of interference occurrence the complete spectrum of the useful signal is known. The last undisturbed spectrum contains all the signal components to continue the production of the currently active audio signal, including all frequencies and amplitudes. After the end of the interference pulse the signal generating proceeds with the calculation of the audio frequencies from the first click-free available spectrum again.

The substitute signal does contain all signal frequencies and their amplitudes at the beginning of the disturbance. This spectrum is put out statically for the duration of the disturbance. On the other hand a "normal" signal is a dynamic ever-changing spectrum. The replacement bridges the glitch thus; although this signal is a signal similar to the wanted signal, this similarity is reduced with the increased backup time. It is therefore all the more (annoying) audible, the longer the glitch. A particularly good replacement coverage results for in spectra with few, slowly changing signals (ideally sinusoidal tones such as CW, less dynamic music), and is not as so good for at speech or noise.

The noise blanker has two settings:

- Level: This value with a variable 0 to 15 defines the threshold level and the signal slew rate at which a signal is to be classified as a glitch.

- ms: Duration of inserting a substitute signal in place of the original signal.

The level value is a level setting of the noise blanker sensitivity. It displays in red during blanking. The higher the score, the more sensitive the blanker classifies signals as a nuisance. "0" is no blanking and at "15" already increased noise or a weak signal with a wideband modulation is defined as a disturbance.

The "ms" value specifies the duration in milliseconds, during which a replacement signal is inserted in place of a detected fault. It is limited to 99. At the latest, after 99 ms a spectrum from the received signal will be generated before re-inserting a replacement signal is possible ("not re-triggerable" noise blanker).

Follow these steps to set the best functionality as follows:

- Place a temporary blanking setting: Common problems require about 50 ms for double sideband modulation and CW reception ("SYNC" or "DSB" and "CW") and 70 ms at single sideband ("LSB", "USB", “EUSB” and "SBCW").

- Increase the level value from 0 to such an extent that the instantaneous received signal triggers the noise blanker. You can see this on the flashing red digits of the level value and the audible signals from substituting the original signal ("machine noise" from fast following blankings).

- Now reduce the level value by a few steps, so that an undisturbed useful signal no longer triggers blanking.

Depending on the type and strength of impulse noise the duration may be adjusted. It should be as short as possible to just bypass the glitch. The level value may need to be changed slightly depending on the received signal, because of the many simultaneous signals in the total range of 164 kHz (eg, tuning the receiver to the middle of a heavily occupied broadcast band) can cause unwanted triggering of the blanker.

The noise blanker also protects the system from interference signals. If the blanking time is set correctly, after the glitch the full receiver sensitivity is immediately available again .

The AM-E and the FM demodulators can not produce substitute signals. Disturbances in the FM mode, of course, has less effect on the signal quality. By using the system as an FM squelch unwanted noise-can cause an increase in the squelch sensitivity. In this case use the AGC manual control or the lower marker ("threshold") for reducing audio noise.

5.10 Videofilter

Function key "F2" allows (except for direct frequency entry) the insertion of a filter function in the image processing of the spectrum display. This can be changed by repeatedly pressing the button between no filtering, average filtering and maximum hold function.

- No: In case a high temporal resolution of the display is needed, the video filter should be switched off. The display will show a very highly dynamic image, with every change in the level (noise) displayed exactly as recorded.

- AVG: Average of the spectral curves of multiple images. The displayed noise will be reduced as short-term maximum and minimum values do not appear in the display.

- MaxHld: The spectrum shows the highest value recorded since the last reset of the display. Here all the detected values are recorded at full processing speed, even if this is above the frame rate (vertical period) of the display, so the actual maximum value might normally not be seen in the display. Adjustment of the maximum hold time can be adjusted for measuring and monitoring purposes.

If you select this filter, the reset rate can be changed via a setting below the caption for key "F2". It can range from 0 (= reset for each new line) up to 9.8 s and then can be set to "infinite". When the reset time elapses all spectral lines will be reset to a zero value. Immediately after this the spectrum starts collecting the new maximum values and will “grow up” until the next reset occurs.

Defines the maximum hold time for an unlimited measurement.

The unlimited measurement time allows the detection of transient signals (monitoring function), which are then displayed as long as desired.

Attention! Any change in the measurement period or the filter function leads immediately to a reset the display!

5.11 Surround sound

The RDR54 has 2 audio channels that can operate independently within the 164 kHz receiver bandwidth. From the user interface 2xx version on, the second channel is phase shifted receiving the same signal as the first

channel (which is always audible).

Channel 2 can be set via softkey "Surround" (pressing the "F5") on the right headphone channel, channel 1 is then only heard left or through the loudspeaker. This increases the audible signal level, but not the noise. The signal intelligibility is improved by the stereo-like sound even further.

The effect of the "surround sound" feature is strongly dependent on other settings. In certain settings, a good effect can be achieved. In addition to bandwidth and shift the exact tuning is primarily of importance. Even a small change in the reception frequency can change the effect, just as the change in the frequency position of the calibration (see the "Memory" dialog). Try different settings if necessary.

When the demodulator is "FM-W" the key is labelled “Stereo” and activates the stereo decoder for a FM radio.

5.12 S-Meter

In the upper panel of the display there is a S-Meter, which is similar to those in analog receivers.

The instrument shows on two scales (above S values with decimals, and S9 +xdB or S0 -xdB, down scaling in dBm or dBµV) the current level inside the audible frequency range with a fast "pointer". To the right there are the smoothed averages (0.8 s) displayed as a digital value. The purple number value indicates the current position of the control / gain setting (upper horizontal line marker). The current unit of the numerical values is also displayed; they can be selected in the "Setup" dialog.

The measured values for the S-Meter can be derived directly from the spectrum. Here the video filtering has to be taken into account, so the unfiltered value, average, or the currently accumulated maximum value is displayed.

When selecting a CW or SSB demodulator, however, it is always a "quasi-peak” reading. Each detected peak value is displayed for a short time, then the value slowly fades down to the current signal level.

6. Dialogues

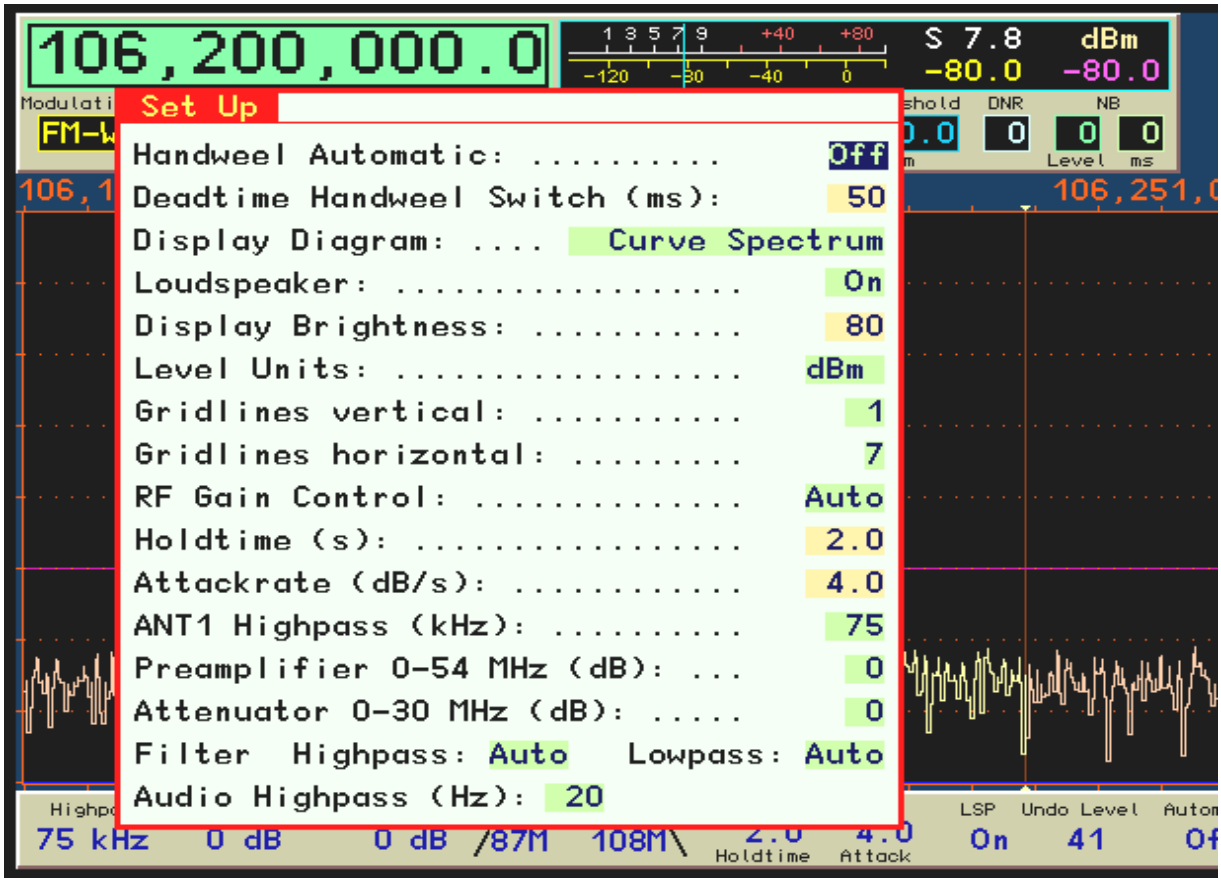
In addition to the permanently displayed user interface, different "windows" or "menus" are available, in which further additional options can be chosen. Those temporary views are called "dialogues".

If a dialogue is opened it changes the function of the control knob from the currently active setting function on the main display to the chosen setting function within the dialogue. The navigation and selection process is the same as with the normal user interface: a selection can be made with the main tuning knob being pressed to skip from option to option. Once you have chosen your option, you can change the value / setting within the option windows by simply turning the main tuning knob.

In contrast to the normal display window color scheme, colors in dialogues are inverted once they have been chosen. Color highlighted values allow a change in the auto-encoder mode (see description in "Setup dialog").

6.1 Setup dialog

Pressing "F3", the dialogue "Set Up" will appear, the spectrum display will be stopped and the dialogue box is shown in the display like this:



In the Setup dialog most basic settings of the device's functionality can be set, their adjustment during normal operation is rarely necessary.

The current status of these values is always visible in the user interface on a panel at the bottom of the screen.

The individual values are as follows:

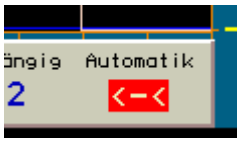
- **Handwheel Automatic**

A value from 0 (“Off”) to 14 sets the rotational speed of the tuning knob and automatically forces the adjustment without the need of user intervention. 0 is OFF, “1” is the lowest speed (very slow rotation) and 14 the highest speed required to trigger the automatic mode.

The system monitors the movement of the tuning knob and takes over its function, once a certain minimum number of pulses per second detected. If this detection threshold is exceeded, the automatic system inserts virtual encoder pulses as sent by the keyboards operating system. These pulses cause exactly the same function (change a setting) as the operator would do using the control knob then tuning a frequency for example, it will have a flywheel effect.

The purpose of the process is to continue a running adjustment, even if the operator has stopped turning the knob. It tries to detect automatically the rate of adjustment in accordance to the measured rotational speed of the knob which is turned by the operator. Once the rotation of the-knob is started, the adjustment of the selected value is automatically triggered.

Once the automatic adjustment has taken over the knob function, it clearly indicates this by flashing a red icon in the lower panel of the display:



The automatic encoder is active.

The arrows to the left and a minus sign indicate the direction of the ongoing adjustment towards lower values (knob was turned anti-clockwise), and the ">" character and "+" symbol accordingly to higher values (knob was turned clockwise).

At low values of the auto setting (activation already at low rotational speeds), first a small increment is set, at higher values of the automatic accordingly higher increment (values will change faster).

During the automatic adjustment, the operator can always increase the adjustment velocity by further rotation of the tuning knob in the current direction. The automatic mode detects these pulses and correspondingly increases the speed up to a maximum specified by the device (depending on the set about 10 - 100 pulses per second).

If the operator moves the rotary knob in the opposite direction, the automatic is immediately interrupted and the adjustment by the user in the opposite direction is executed. Effectively, therefore, the last automatic pulse is reversed.

The automatic mode is also stopped under the following circumstances:

- Any key or the tuning knob is pressed.
- In case it will reach a final value of a setting (sometimes not fully visible)
- The upper horizontal marker (manual gain control or automatic gain control) is moved at least one position up or the received signal exceeds the marker within the audible area. This is especially helpful when tuning a frequency, as it is immediately turned off in case a strong signal comes into the audible reception area.
- Request for a display scan through the USB interface.

The hand wheel automatic mode is not available for all adjustments, but only for those with more than about 20 possible values. In dialogues, these values are highlighted in light colors.

- **Deadtime Handwheel Switch (ms)**

When pressing and releasing the adjusting knob (pressing the internal mechanical switch), an occasional accidental click step is sometimes carried out. This happens especially with magnetic latching rotary encoders, since they have a very "soft" cogging and no audible snap sound.

For the rotary encoder button, a "dead time" needs to be set. If the knob is pressed or released, the rest steps are then only allowed after the time lag. Those steps that happen during the dead time are ignored.

The time delay also acts "backwards", ie for rotations **before** pressing / releasing the main knob. If this press / release occurs within the dead time since the last rotary motion, then the last executed steps (which occurred due to the rotation) will be undone.

Select a value for the dead time to remove accidental steps that occur in setting procedures when you press and release the knob. This value is depending on personal feeling and skill, the built-in encoders and practice in the device operation.

Note: A high value requires a long wait for rotations or press / release, before you can continue to operate! Otherwise, the final intended use is always made undone, which is also undesirable.

- **Display Diagram**

- Curve Spectrum: The spectrum is shown as a connecting line between the level values in each spectral line. The usual representation of a spectrum.

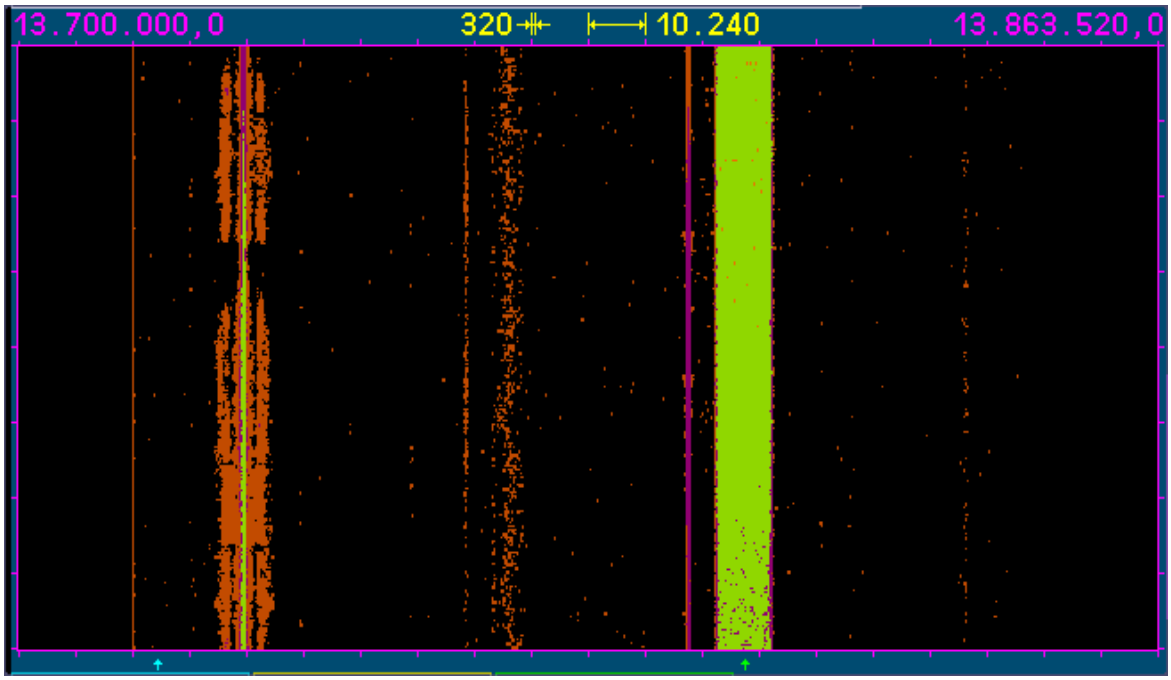
- Line Spectrum: Each spectral line is drawn from the lower boundary up to its level value (equivalent to "fill" the display below the curve spectrum).

- Waterfall: The spectrum is shown as a waterfall diagram.

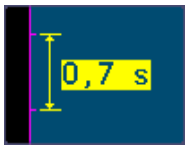
So-called "waterfall plots" are an important tool for recording and documenting signal changes over time. Thus, each recorded two-dimensional spectrograph will not be displayed with the frequency on the x-axis (horizontal) and the signal level on the y-axis (vertical), each new plot overwrites the old one immediately and irrevocably. Rather, the level meter will now be scaled to almost the depth level (z-direction). Since this third dimension in a graph is not possible or representable, the level is now coded in colors and the spectrum is written as a one-dimensional line in the diagram.

Imagine you would take the usual spectrum display into your hands, turn it by 90° around the horizontal axis with its “tips” directed to you. Now look down to the edge of a thin "spectrum-slice" where the parts closer to you are bright and the tips further away from you (valleys) are in darker color.

This slices are now continuously drawn in the display, older slices moving downwards, while newer slices appear at the top of the display. The newest one is always drawn on top, the oldest slice disappears below the diagram.



The effect corresponds to a visual impression of a waterfall, hence the name of this display.
The "fall velocity" can be selected in three steps.

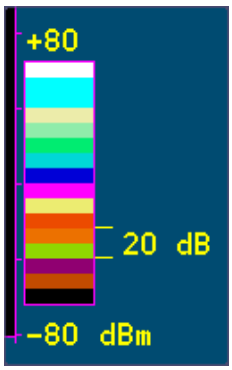


The diagram is moved at a speed of 0.7 sec / unit = 17.5 ms / line (spectrum).

Note: The calculation speed of the spectra is independent of the selected running speed and always equal to 4 times that of the selected spectral line width, in the example shown, ie 1280 spectra / s = 0.78125 ms / spectrum. To prevent data loss, select the mean or at very high data rates (for example) the maximum value for the video filter. Set the refresh rate to somewhat higher values than the line speed of the waterfall's one. If necessary, increase the line speed to the maximum value (0.35 s / unit = 8.75 ms / line).

Conversely, at high resolution and correspondingly lower spectra rate per second, possibly less calculated spectra are plotted as lines are drawn. That causes no data loss, but the plot is less informative, as more and more lines are drawn with the same content in succession until a new spectrum is available. In this case, reduce the speed of the Waterfall chart and / or turn off the video filter.

The view of the waterfall is heavily dependent on the "viewing depth" of the underlying level position in the diagram. The indication of the level takes place as color coding. Which colors are used for each level is shown in the color chart.

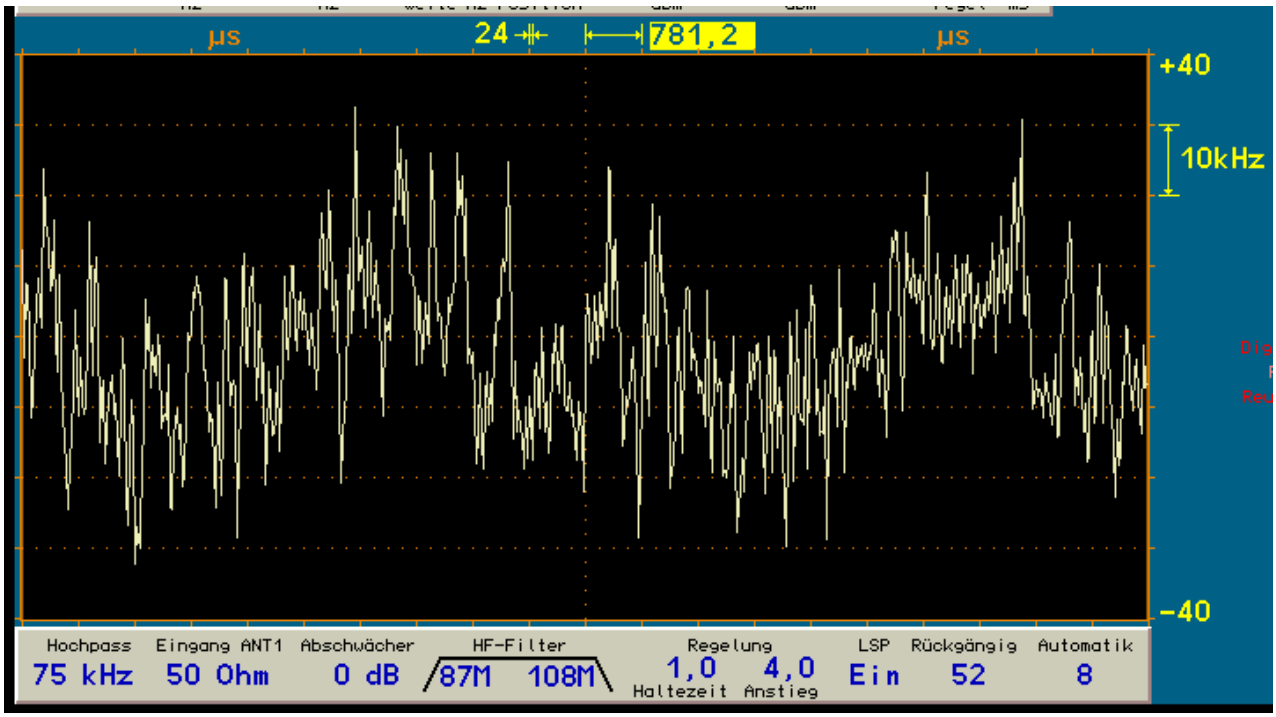


The color chart shows the representation of the signal level in color steps.

The colors displayed correspond exactly to the magnitude of the normal spectrum display and can be altered as well. The colors themselves can not be changed.

Note: Select the level position of the spectra (selecting the upper setting value) for the highest possible contrast so that the area of your level of interest is displayed in large color differences. For example, the noise threshold should be adjusted so that already little peaks of a signal are coded as a next color step. This way even low signal levels result in a clearly visibility trace above the noise floor.

- Oscillogram (FM-W only): shows the diagram of the timeline (not of the frequency domain as spectrograms) of the output signal of the stereo decoder.



The oscillogram records the time line of the amplitude of the LF signal. On the left side to the center the left channel is shown, on the right side the right channel. The horizontal scale is now in units of time (rather than frequency), the vertical scale corresponds to the amplitude represented by the deviation of the original FM-modulated signal.

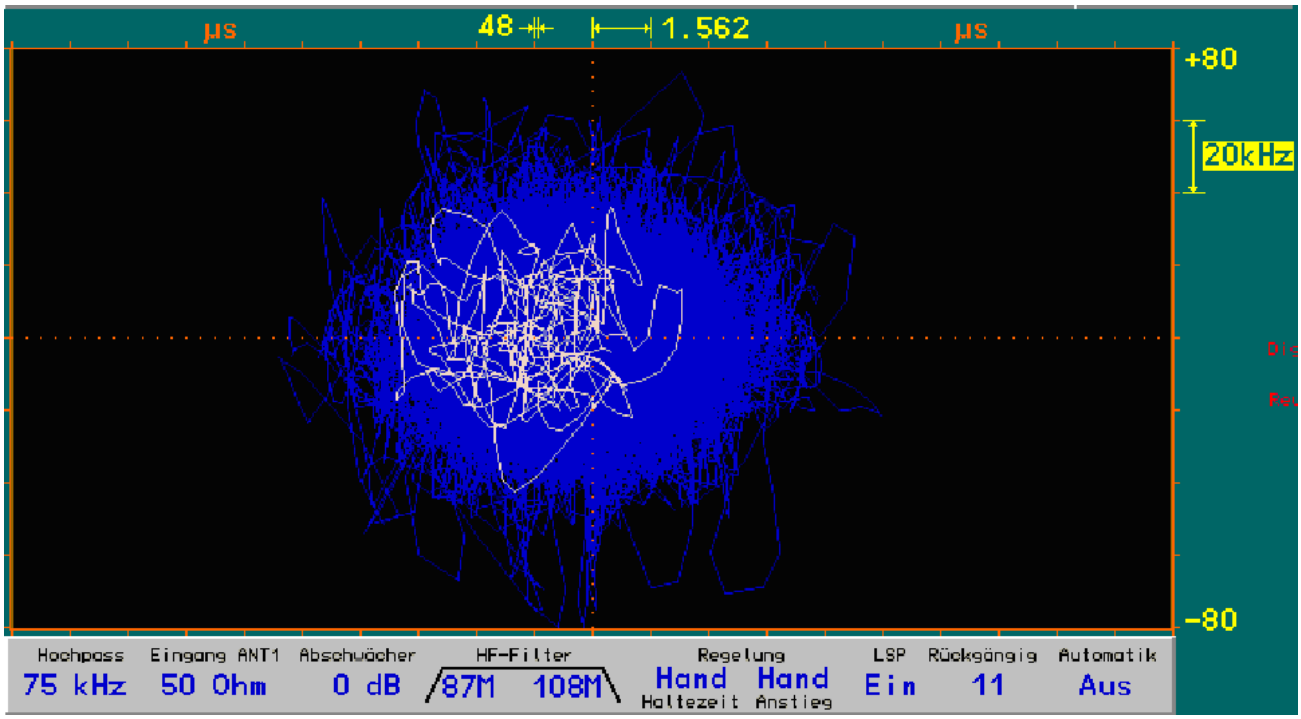
The adjustable time scale lets you select various sampling rates and thus the "stretching" or "compression" of the diagram in the horizontal direction.

The unit "kHz" for the amplitude results from their direct proportion to the deviation of the FM signal. Here, a signal represented by "0 kHz" (vertical center of the diagram) is the demodulated value at exactly the carrier frequency, amplitude values are indicate exactly above or below the current modulation of the FM signal. The oscillogram can therefore be used for the modulation measurement.

The oscillogram is "DC-coupled", any deviation of the RF signal from the exact carrier frequency causes a vertical displacement. It can thus be used as "tuning aid" for FM signals.

Note: The oscillogram, in conjunction with the stereo test generator (see section "Special Features"), can be used for the measurement of channel-crosstalk.

- Goniogram Line (only FM-W): Phase diagram of the output signal of the stereo decoder.



The Goniogram draws a diagram of the time-dependent spatial (two dimensional) amplitude and phase distribution of left and right channels. This gives the deflection in the horizontal (x-) direction, the amplitude in-phase signals (sum or mono signal), the deflection in the vertical (y-) direction, the amplitude of unequal phase signals (differential or stereo signal).

The scaling of the x-axis shown here is incorrect, it is just like the y-axis the amplitude represented by the modulated signals deviation. The x-axis settings were left for the sake of clarity, as in the oscillogram. Even here they are again setting the sampling rate (time between two samples).

The Goniogram always consists of 512 samples of left and right channels. The coordinates of the continuous samples are shown as a line from the last to the current sample. After 512 samples, the resulting line is deleted and the drawing of the next starts.

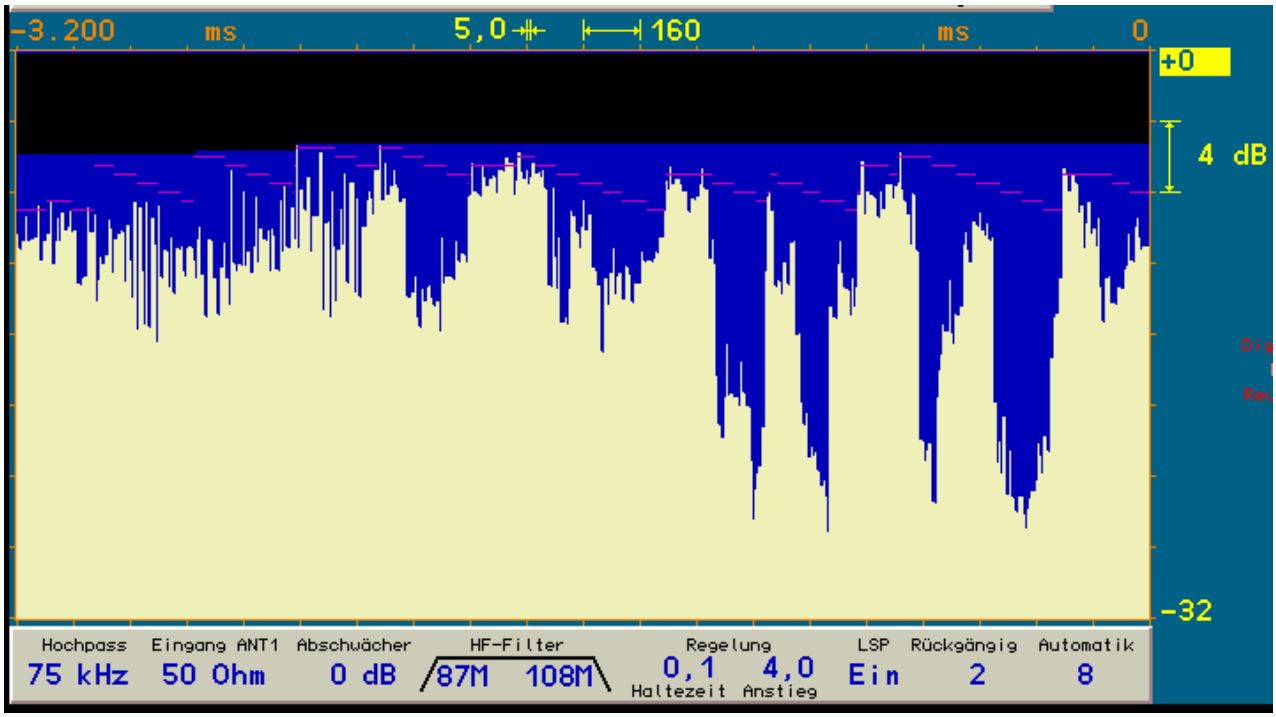
Note: When using the maximum-hold video filter (as shown above), older lines are not deleted immediately, but during the measurement period of the filter shown in blue. The current drawn is always shown in yellow (or green). As the drawing process is very rapid, with the maximum-hold a longer storage and visualization of the obtained amplitude values is possible. The same applies to the oscillogram and the histogram.

Note: The Goniogram, in conjunction with the stereo test generator (see section "Special Features"), is useful for a variety of measurements and signal representations ("Lissajous figures"). In particular, the filtering properties of the receiving channel from the ADC output to the stereo decoder can be assessed in terms of amplitude and phase distortion well.

- Goniogram Dot (FM-W): Phase diagram of the output signal of the stereo decoder.

As above "Goniogram Line", the coordinates of the samples are shown but only as individual dots and not continuously connected with a line.

- Histogram (FM-W): Time / amplitude diagram of the output signal of the stereo decoder.



The histogram is a "waterfall graph" that runs from the right (present) to the left (past). It shows the time-dependent amplitude of the modulation level for the resulting audio (L and R are added).

The vertical scale in dB is the audio level at the time. "0 dB" means a nominal modulation at 75 kHz deviation, taking into account the (stereo) Pilot and RDS signal (standard signals of an FM broadcast station).

The speed of the histogram can be selected with the horizontal scale. There is also a possible stop (value is shown as "STOP!"). The absolute times (orange numbers) are then represented in negative times (as past). When restarting, the time on the left side is immediately scaled proportionally to the present and is false as long as all the old lines (from the downtime) are overwritten.

Note: The histogram can be used to judge the quality of the modulation when using dynamic compressors and exceeding the permissible modulation swing.

Note: In the histogram the current position of the top horizontal marker appears. When using this diagram, the marker acts contrary to the common RF level adjustment. That is, levels less than 0 dB will be reduced the farther away they are from the 0 dB mark (decompression). The effect depends on the setting of the diagram and can generally be varied by changing the "DNR" setting of the user interface (at FM-W this setting is labelled "DCM" for "decompression mode"). Setting to zero prevents any signal degradation.

- **Loudspeaker**

The internal speaker can be permanently muted ("Off", useful for pure headphone use). If the speaker is muted, the volume knob to change the headphone volume does not need to be pressed.

- **Display Brightness**

Adjust the brightness of the display and the keyboard-LEDs in steps from 0 – 100. Settings below step 5 at “power on” or “accessing a memory” will be set to 5.

- **Level Units**

Scaling (y-axis) of the spectrum or waterfall chart and the S-Meter in dBm or dBµV.

- **Vertical and horizontal grid lines**

Dotted lines in the spectrum graph to better view the sub-units.

- **RF Gain Control**

- Auto: The gain of the received signals (and thus the volume of the audio signals) will be adjusted automatically.

- Manu: The gain can be adjusted manually by moving the upper horizontal marker.

- **Holdtime (s)**

The time between detection of a reduced signal level in the spectrum up to automatically increase of gain in automatic control.

- **Attackrate (dB / s)**

Speed at which the upper marker in order to increase the gain is adjusted automatically.

- **ANT1 Highpass (kHz)**

Into the signal path of "ANT1", a coupling capacitor to increase the lower limit frequency is activated. By default, a capacitor for a lower cutoff frequency of about 1 kHz is available. In addition, a capacitor of about 75 kHz cut-off frequency can be switched on (loss of audio signals and especially mains hum).

- **Preamplifier 0 – 54 MHz (dB)**

Into the signal path of "ANT1" and “ANT2”, an about 15 dB amplifier for decreasing the noise levels can be switched on. Available only for RDR54 version “D”.

- **Attenuator 0 – 30 MHz (dB)**

Into the signal path of "ANT1", a -20 dB attenuator for increasing the clipping free RF-level can be activated.

- **Impedance 0 – 30 MHz (ohms)**

Into the signal path of "ANT1" a (idealized 0 ohms) amplifier with very low input impedance can be switched on ("Current sensitive input"). Available only for RDR54 version “C”.

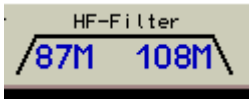
- **Filter Highpass / Lowpass** (Switching of the high-frequency filter)

- Auto: Automatically set according to the actual receiving frequency.
- Fixed values below 50 MHz: Fixed turning on the appropriate filter.
- Fixed value of 50 or 54 MHz (no matter which filter): Fixed filter and use of antenna input ANT2 in the range 50 MHz to 54 MHz.
- Fixed value of 87 or 108 MHz (any filter): Fixed filter and use of antenna input ANT3 (only for existing FM module).
- Fixed value of 144 or 148 MHz (no matter which filter): Fixed filter and use of antenna input ANT4 (only for existing FM module).

- No high-frequency filter connected, except fixed-aliasing filter 31 MHz and input coupling capacitor 1 kHz or 75 kHz.

Note: The RDR54 digitizes a frequency range from 0 Hz to 150 MHz. With only one built-in signal processing board RDR25 merely an area of 163.84 kHz is used effectively. To avoid interference due to frequency signals located far away and to increase headroom, various high-frequency filters in the signal path from the antenna to the A / D Converter are available. In addition to fixed switched filters for the respective frequencies of the antenna inputs, in the range up to 30 MHz a series of high- and low-pass filters are switched (see technical data). RDR54 version “D” even includes a tuneable preselector.

The current signal path is displayed by the following graphic.



The left value indicates the current high pass filter, the right value the low-pass filter. In the range of 500 kHz to 18 MHz version “D” shows only one frequency (resonance frequency of preselector). In this case the value can be altered manually or automatically.

Attention! The range of 50 MHz to 54 MHz can be selected only in the filter-automatic mode by tuning the frequency into this range (overflow of 30 MHz directly to 50 MHz), or a filter (whatever) is placed on this area (no overflow of frequency permitted). The same applies to the areas of the FM module.

Attention! Using the filters reduces the measuring accuracy of RDR54! Use it for measurement proposes only for the 6m (FM) area or in high noisy environments in the range up to 30 MHz.

Attention! When switching the fixed filters on, the accuracy of RDR54 at a frequency setting outside of the filter area is completely undefined! Likewise, when selecting the high-pass filter 75 kHz in the range below about 100 kHz. The same applies when manually tuning the preselector different to the receiving frequency.

Attention! When selecting the input impedance preamp with 0 ohms, the level of scaling is totally undefined!

- **Audio Highpass (Hz)**

Highpass filter for all audio processing. Can be set between 20 Hz and 200 Hz to suppress unwanted low frequency audio signals (hum and so on).

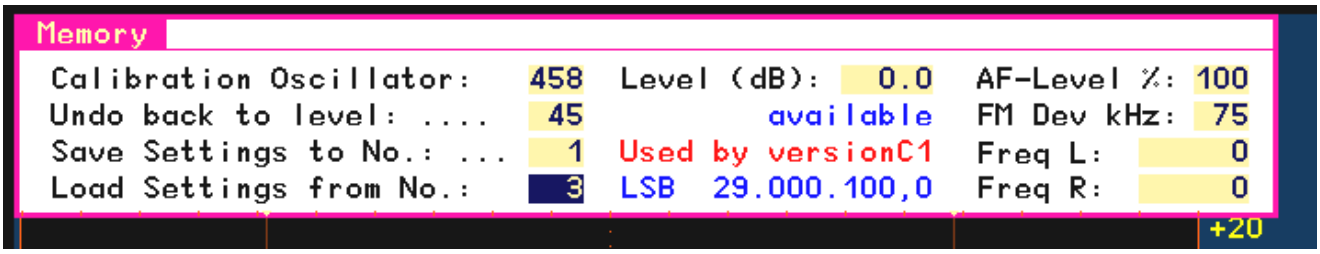
- **Audio Lowpass (kHz)**

Lowpass filter for all audio processing. Can be set between 0,5 kHz and 15 kHz to suppress unwanted high frequency audio signals (noise etc.).

The Setup dialog must always be closed by pressing the "F3" (key LED flashes with this dialog opened). All settings in the dialog are stored permanently and their values are now used for the further functioning of the equipment.

6.2 Memory dialog

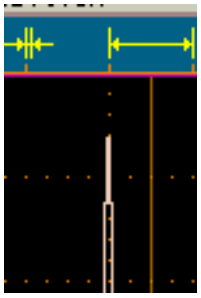
The soft key F4 labelled "Memory" brings up a dialogue in which additional device functions can be user defined. In this dialog the settings for the calibration of the RDR54, parameter storage as well as other device settings are available. Further, the operation of a test generator for various purposes is possible. With the Memory dialog open the spectrum display will continue to run.



The following settings are possible:

- **Calibration Oscillator**

The main oscillator of the RDR54 can be adjusted. The indicated set corresponds to a dimensionless value that is used by the adjustment system for calibration of the oscillator. Ask for precise calibration of a well-known signal (or reasonably accurate frequency standard radio station) with high spectral resolution (optimum 2.5 Hz / line) so that the frequency corresponds to the center of the spectrum display.


Precise calibration.

Adjust the oscillator calibration in such a way, that the carrier appears as pictured above with exactly the same level in line 319 and 320 (center line of the diagram). Turn on at least one vertical grid line for identification.

Attention! The setting of the calibration has great impact on the quality of audio production, and the accuracy of RDR54!

Attention! When selecting the calibration stage "999", a test generator is activated, which sends its signal instead of the ADC data to the signal processing! For further information see section "Special Features" - "Test Generator".

- **Level (dB)**

An adjustment of this value causes a vertical shift of the display in all spectrograms by the set value and therefore a change of level readings. Use it when you need to make an accurate level setting using an external reference.

- **Undo back to level**

The device stores the last 63 continuously operating steps you have made. You can always call one of these settings again (see description of special functions "Undo"). Setting "0" always contains a factory defined default setting.

- **Save Settings to No.**

The current device settings can be saved to one of 63 memory locations permanently. Select a location for the backup. Any information in former storage in this place appears before anything is saved, or whether it is still empty. The red marking is used to signal that something might be overwritten! Backups of the complete current device status are always created without further warning **if the dialogue is closed with this setting selected and pressing the "OK" button (F5)!**

- **Load Setting from No.**

You can load a saved setting from this memory location. Any information in the stored setting (demodulator + frequency) appears, if there is a valid setting on the selected location. Otherwise the location is declared empty or used by other software. **Location 0 leads to load a very special setting, the "Boot loader"** (see description of special features: Software Update).

- **AF-Level (%)**

If the test generator is activated by choosing setting “999” for oscillator calibration, here the amplitude of the test signals can be adjusted. If both selected frequencies are greater than zero, the level of both signals is automatically halved to avoid clipping. For further information see section Special Features "Test Generator".

- **FM Dev (kHz)**

If the test generator is activated by choosing setting “999” for oscillator calibration, here the deviation of the frequency modulation can be adjusted. For further information see section Special Features "Test Generator".

- **Freq L**

If the test generator is activated by choosing setting “999” for oscillator calibration, here the frequency of the first audio signal can be adjusted (usually used for the left stereo channel). For further information see section Special Features "Test Generator".

- **Freq R**

If the test generator is activated by choosing setting “999” for oscillator calibration, here the frequency of the second audio signal can be adjusted (usually used for the right stereo channel). For further information see section Special Features "Test Generator".

The Memory dialog has to be closed with either the F1 key (Function "Escape" = Discard the settings) or F5 ("OK" = Activate of the settings). To indicate the necessary usage of one of these 2 buttons both key LED flashes.

Pressing F1 will conduct no further changes in the device setting. However, calibration of the oscillator and level or frequency settings are always executed immediately after a change of setting inside the opened dialog and stored permanently. If you press F5 and have select a memory location or an undo level, the function is always executed: the current instrument setting is saved or restored completely (if applicable!).

7. Special Features

All previously described instrument settings and functions are the appropriate to the use of the RDR54 and will be required more or less often. Some features are rarely or perhaps never necessary, but must still be implemented and documented.

The variety of possible settings and operations of the RDR54 can possibly lead to undefined or obscure settings. Switch-off and restarting the device brings no help in this case: All device settings are always stored non-volatile, the RDR54 starts again in exactly the same operating state it was on shut-down, even after a long time with an unplugged power cord.

To set the device to a known operating state, you have several options:

- The "Undo" function.
- The initialisation of a start-up status, called the "factory setting".
- The complete deletion of almost all software in the device and (re-) load the old or new software ("Software Update").

7.1 Undo Function

Use this feature if you ran only a few operating steps that have led to an unsatisfactory or confusing setting state of the device. You can get back the setting state of the device to one of the last 63 operating conditions. Note the instantaneous state "Undo Level", which is always displayed in the panel below the spectrum diagram:

The device is currently in state "49".

Now try to define a certain number of operating steps from where you want to undo the settings and subtract this number from the current state. You have to calculate a possible “underflow” to negative values as the countdown to the highest possible value of 63:

Example: Current state 8, desired return of the instrument setting of 10 Steps:

8-10 = -2 à (0 corresponds to 63) à 63-2 = 61

Open the Memory dialog. Select the setting "Undo back to level:" and set it to the desired undo state (as per example "61"). Close the dialog by pressing F5 = "OK". The device is set to the state that existed when the last time "61" stood in the display.

Note: The Undo value is always incremented by actuation of keys (ie the state of the equipment is stored). This includes pressing the knob (more precisely, just when releasing it). You can always trigger a complete storage of the device setting by briefly pressing and releasing the adjusting knob. Remember or write down the displayed undo state if you think you possibly will reverse the next device setting.

Note: At switch-on the setting of the device is restored to the level displayed when switching it off. If you make a note of the displayed value immediately after switching on, you can return to this power-on state up to the undo-system overflow (ie the automatic reuse of this space).

The readout of the current undo level has a secondary function: After switching on the device the field is shown in red for a few seconds. In this time the RDR54 checks all internal components, software and hardware. When the red marking disappears it signalises the end of this check to be successful.

When you switch off the RDR54 during the check it will remember this as a not successful power cycle. More then 3 times of such incomplete power cycles causes the start of the Bootloader instead of loading and starting the common display again. This gives the chance to upload new software in the situation of former falsely loaded files or any corrupted functionality that denies starting the Bootloader in the normal way (“Memory” dialog).

7.2 Defaults

Number “0” of the undo function cannot be overwritten and is always containing a clearly defined factory setting. You can load this setting if you can not find any useful or desirable setting in the undo buffer system.

Note: You can also use manually allocated memories (if used) in order to load custom settings saved by yourself on a certain place. These memories will not be changed or overwritten by the Undo function.

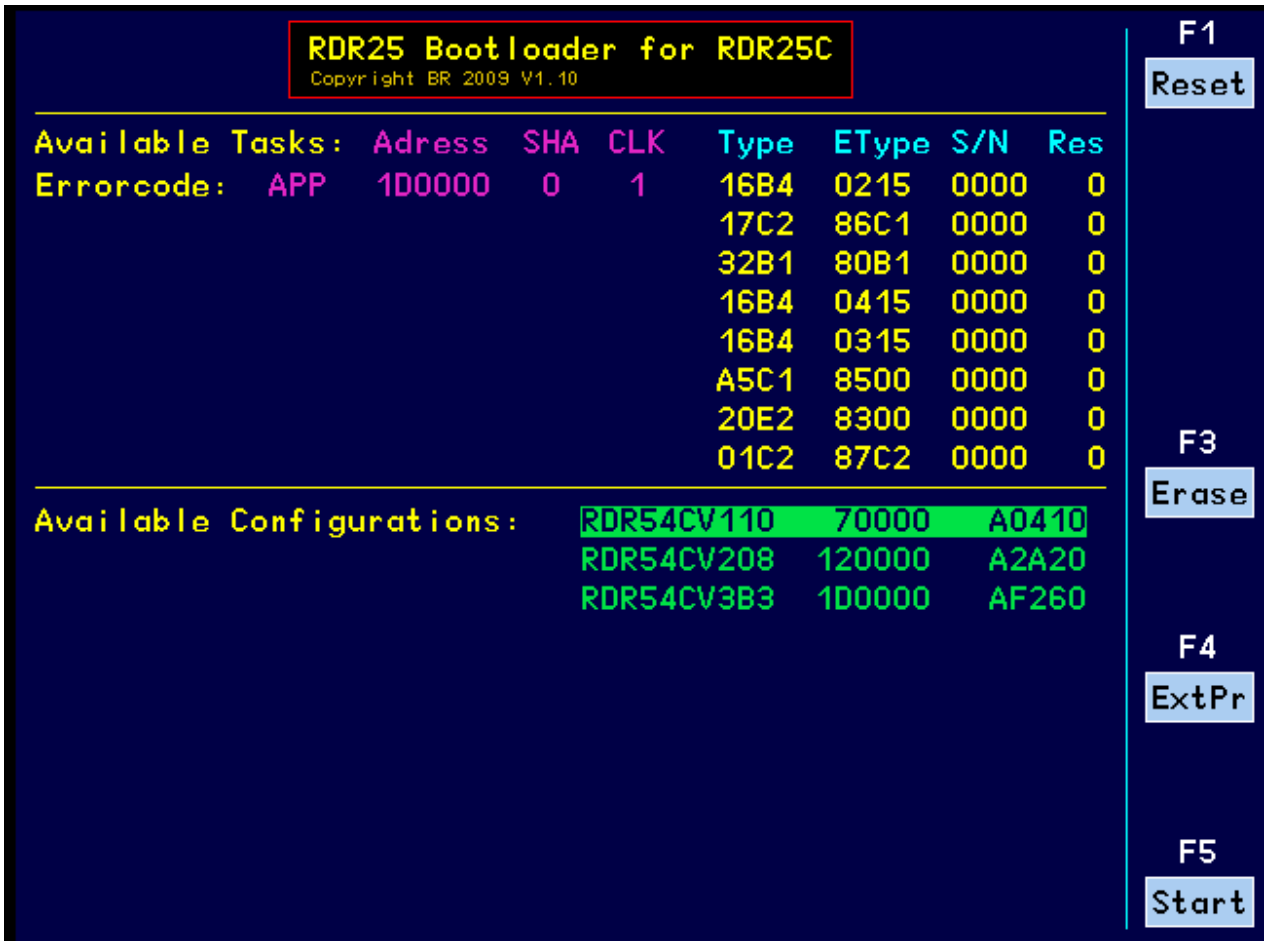
The factory default sets all the parameters either to its smallest (eg frequencies) value or for a useful operating condition (eg brightness).

7.3 Software Update

The RDR54 allows extensive customization of functionalities implemented by the programmed firmware which can always be restored by connecting it to a personal computer (PC). The software creates not only in the usual sense the "software", say specified programs of microprocessors, but also the configuration files used in programmable logic devices ("FPGA" = Field Programmable Logic Array à free matrix of programmable Logic units), thus the existence of complete units such as processors and interfaces within the device (so-called "soft cores"). Only a few units are designed in “true”" hardware, such as the A/D and D/A converter, power supply or keyboard controller. Even the WVGA graphics chip is an FPGA, and thus can be software defined from scratch.

- **Bootloader**

  Upgrading the software uses functions of the device's internal operating system. This is realized by an interface program, called "Bootloader" (loader for software).



The Bootloader is non-volatile firmware programmed into the signal processing board RDR25 and can be started by choosing the value 0 of the setting “Load Settings from No.” in the Memory dialog. All currently running tasks in the device (sub-programs of the various modules) with their identification numbers will be listed, as well as the stored main programs on the RDR25 card, so-called “Configurations”.

Normally, the card includes one or more configurations for the realization of the device function "RDR54CVxxx", where "xxx" is a number that describes the version of the user interface. Such a configuration can be removed by pressing "F3" key, or started by pressing "F5". By pressing "F1" the unit can be restarted without changes, "F4" transfers functionality of the device to an external program (such as other signal processing boards, which also contain configurations).

Attention! Never delete all configurations of the device, without being sure to be capable of reprogramming a new configuration! Should the device (more precisely, the RDR25 module) contain no configuration at all, the only device function still possible will be to start the Bootloader!

Warning! When you delete a configuration, all subsequent configurations are deleted from the list too! Previous configurations will remain.

Note: Starting a configuration with "F5" can sometimes lead to incorrect functioning of the equipment (the user interface RDR54 does not appear in the display). The reason is that some modules (plug-in cards used) require a power shutdown. Switch-off and turn the device on again after a few seconds in this case.

If even after the power cycle and pressing F5 again no device function (RDR54) can be obtained, the Bootloader appears again. In this case one / several tasks (a plug-in card) is defective, does not exist or has no software stored (identification “EType” contains BDxx). Load in the latter case new software as described below. If this doesn’t help, the device is defective and must be taken out of service. Send it in for repair if necessary to the supplier / manufacturer.

Software Download

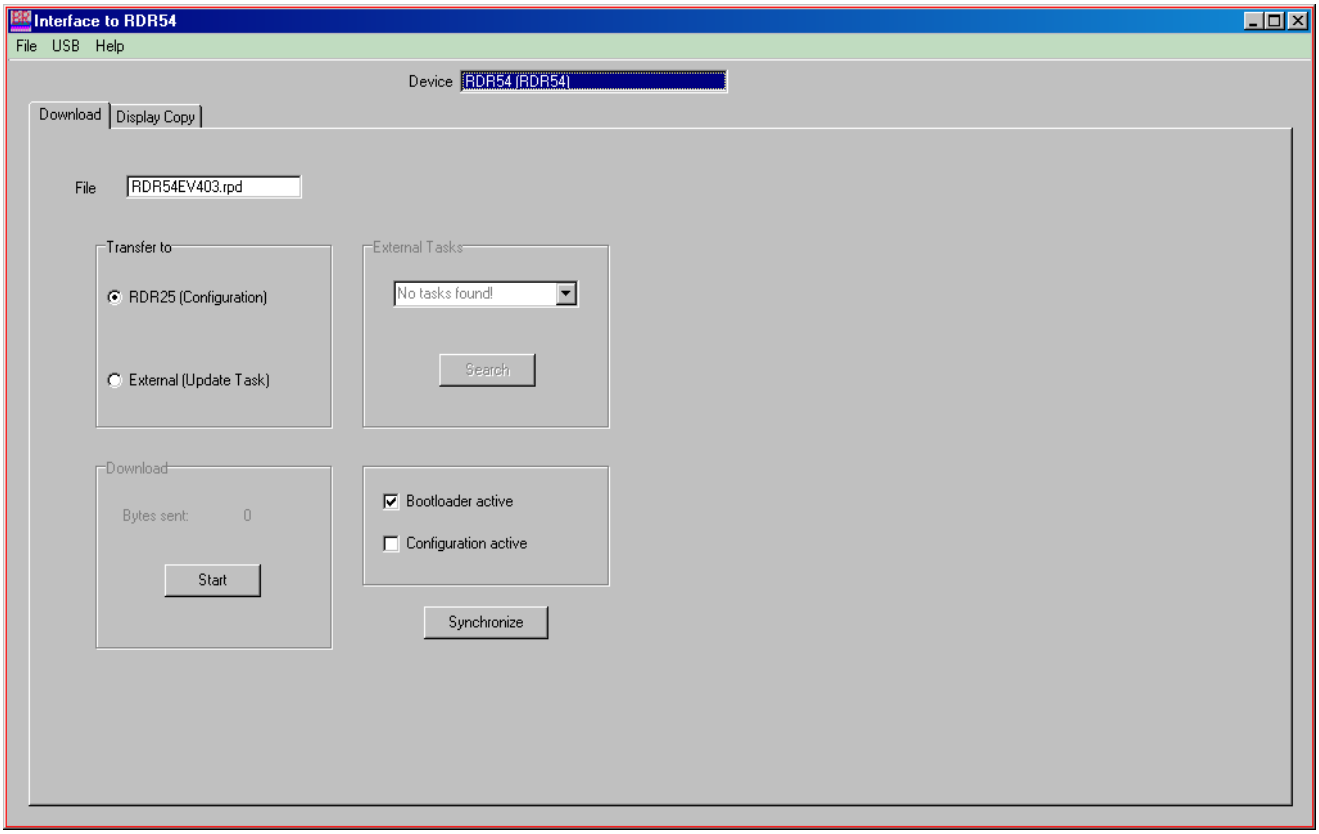
A download (storing) of a new software requires connecting the device to a PC via a **USB interface (version 2.0 "high speed" required**) and the correct installation of the so-called "device drivers" for recognizing the RDR54 as a connected USB device. You will need a **PC running Windows XP SP2 or Windows 7 32 / 64 Bit!** You should proceed as follows:

- Insert the included CD-ROM into the CD drive of your PC.
- Connect the RDR54 using the supplied cable to a USB port.
- Turn on the power.
- On your PC an installer (or "wizard") will be started, which asks for the device driver for the RDR54. This driver is called "CYUSB.SYS", the related information file for Windows "RDR54USB.INF" and is on the CD. Lead the installation wizard to this file and follow further instructions.

Attention! Driver and PC software for use with the operating systems Windows XP SP2 to Windows 7 are provided. They assume the correct operation of the PC and the operating system. Depending on the version of the system, the installation program is different for loading device drivers. Refer to the instruction manual for problems or help function of your computer / operating system!

Attention! The operating system Windows 7 64 bit needs to be started with disabled driver signature enforcement to activate the CYUSB.SYS driver!

After installing the driver your PC detects a device "RDR54 (RDR54)". Perhaps a repeated switching on and off or disconnecting and reconnecting the USB cable is necessary. For uploading and downloading of software there is a program "RDR25A.EXE” on the CD in the folder "RDR54". Copy this folder with all the files in any folder of your PC. Start ("Open") the file RDR25A.EXE from this folder. The user interface of the program appears on your monitor.



In the text box "Device" RDR54 must be displayed. If necessary, you can search through the menu item "USB" for existing equipment. If there is no entry in the "Device" box, then the USB driver is not installed correctly or the RDR54 is not connected / switched on. Make sure the receiver is connected properly and check the installation in the device manager of PC and install the driver manually if necessary!

The firmware to program into the RDR54 always has the extension ". RPD", eg "RDR54CV300.RPD". The CD contains some of these files. The file whose name always starts with "RDR54" is a configuration file for the device. In order to load them in the RDR54, proceed as follows:

- Start the Bootloader (dialog "Memory" à Load Settings from No.: à 0).
- Click on the button "Synchronize", a check mark must then appear in the check box "Bootloader active."
- Select via the menu item "File" and select "Open" and open the desired file. The file name must appear in the box "File".
- Click in the "Transfer to" box on "RDR25 (Configuration)" if this point is not already selected.
- Click in the "Download" box on button "Start". The "Bytes sent" now displays the number of bytes transferred consecutively.
- At the end of the transmission, a window appears indicating the successful transmission.
- For errors, a message window appears with a note on the error (eg "Device not responding"). Then turn the unit off and back on, start the software interface and repeat the entire procedure.

Attention! Do not turn off the device or the PC during the download and never disconnect the USB connection!

Note: If the message "Software can not be saved!" appears, the memory is full, no more configurations can be loaded. Delete stored configurations in this case (key "F3").

In the Bootloader of the RDR54 the newly loaded configuration is displayed (possibly reset required). The transferred configurations are stored sequentially. One of them can be selected using the knob and can be started by pressing the "F5" (possibly turning off and on the equipment is needed).

In addition to the configurations for the definition of device functionality, also all auxiliary functions ("tasks") of the various modules can be reprogrammed if the hardware allows it. Such tasks can be selected for update by

checking the item "External (Update Task)" in the "Transfer to" box. Proceed as follows (the correct synchronization with the Bootloader as described above is provided):

- Click in the "External Tasks" box on the "Search" button. It will generate a list which lists all the tasks in the unit available for updating their firmware. The first entry appears in the box above the "Search" button.
- Select the desired Task.
- Open the file ("File" menu à "Open"), which contains the software for the selected task.
- Click on the "Download" box the "Start" button. The "Bytes sent" label displays "Clearing memory ..." and the positions of the erased memory chips (usually only one chip with the "0") for a few seconds.
- After clearing the memory it returns to the counting of transferred bytes and the note at the end of the transfer.

Attention! Make absolutely sure that you transfer the correct file for the selected task! Wrong software causes no function or even results in damage to the device!

Note: Tasks can only store one "configuration", so the memory will be automatically erased before reprogramming. In case of a possibly occurring transmission error, the critical part of the software remains in the task memory and will not be erased. This way, the task can still run and remains accessible. After a reset, or a power off / on cycle, the task returns to the list and can be reprogrammed. The task has now a new identification number, the associated parameter "EType" always begins with the value "BD" (reference to the protected function "boot-device"). Please inform yourself in the info-file of the download files, which reference number the tasks in your receiver have in the normal functionality and which ones as a protected “boot-device”.

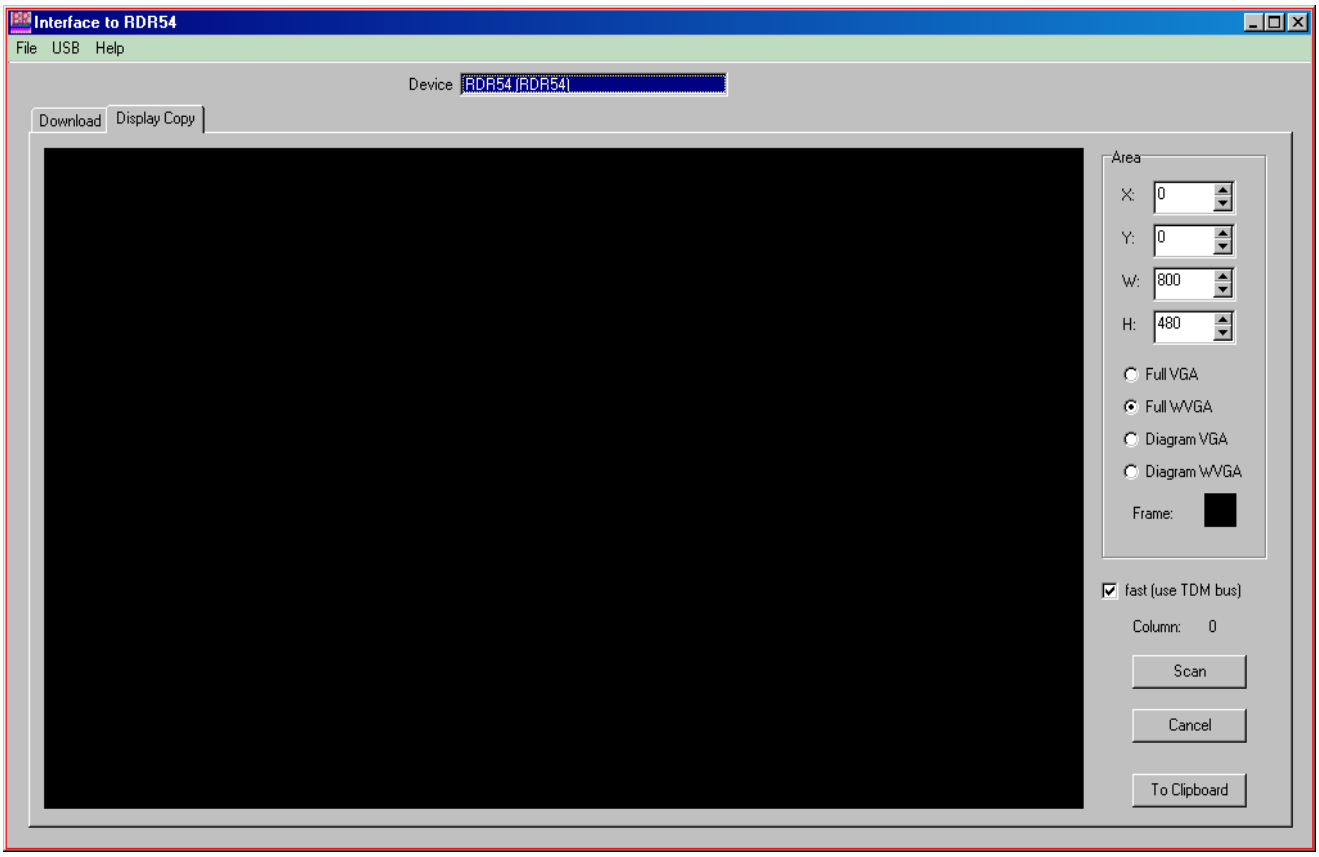
Note: Running configurations in case of active boot devices is not possible. You must always store useful software into all external tasks (“EType” must not contain “BD” in the first two letters).

Note: Even if programmed successfully, boot devices will run always until the power is switched off. The new software starts up only at the next turning on the device.

7.4 Upload of Data / Display Copy

The RDR54 permits reading data from the device via the USB connection. This refers to the output of the display content ("Scan" function) and the raw data output from the signal processing including remote control of the RDR54 from the PC. The latter application is a special case and is independent of the actual functioning of the equipment provided / documented.

Saving and printing of display content is often necessary to document reception conditions and measurement results. This function is also available in the RDR54 interface program. Simply click on the tab "Display Copy".



You can select any section of the screen to be copied and transferred to the PC. Select it using the pixel coordinates of the upper left corner of the area (X and Y, starting with 0 from top left). Set the desired width (W) and height (H) of the section to copy one. If useful select a suitable preset setting and the color of the background (click on the color box behind "Frame"). The visible blank image is adjusted according to your choice in size and color.

Start the copy process by clicking the button "Scan". The screen content of the unit's display is now transmitted column by column from the left and appears in the picture. In this case, a frame around the transferred image is maintained by each 5 pixels after the final scan on all sides. During the operation of the transmission it is not possible to control the RDR54 and no screen updates occurs. In the readout "Column" the current progress of the transmission can be seen. It ends with a success message or aborts with an error message. Restart after cancelling the scan if necessary. Wait for it until the RDR54 reacts to input again!

Attention! You should use a PC with enough processing power and configure it (active programs) that no application software or operating system is blocking the data transfer. If the PC is not in a condition to edit the received data immediately the scan aborts.

The image can be used for further processing via the menu "File" à "Save" in the BMP format, or taken over by clicking the button "To Clipboard" directly into the Windows clipboard.

7.5 Test Generator

In the Memory dialog, a test generator can be activated by setting the calibration frequency to the value "999". The generator is fully digital and feeds its data instead of data from the ADC into the signal processing chain. The received data from the antenna will be ignored in this case.

The test generator generates a digital high-frequency signal with exactly the frequency which was set when it is activated as a receiving frequency. It remains intact even if the memory dialog is closed. Frequency of the receiver changes have no effect until the dialog will be opened again. At that moment, the generator takes over the current receive frequency.

The output level of the test generator can be varied over the setting "AF level" from 0 to 100%. All values greater than 1% of the generator operates as a stereo coder and also help generate the necessary auxiliary

signals (subcarriers, pilot tone, differential signal). When set to 1% no stereo signal is generated.

When set to "FM deviation", the test generator can be frequency modulated. The two test signals, and in the case of the stereo operation, the auxiliary signals are modulated onto the RF carrier. When set to "75 kHz", the generator produces a standard FM stereo signal like a radio transmitter. It creates no RDS signal.

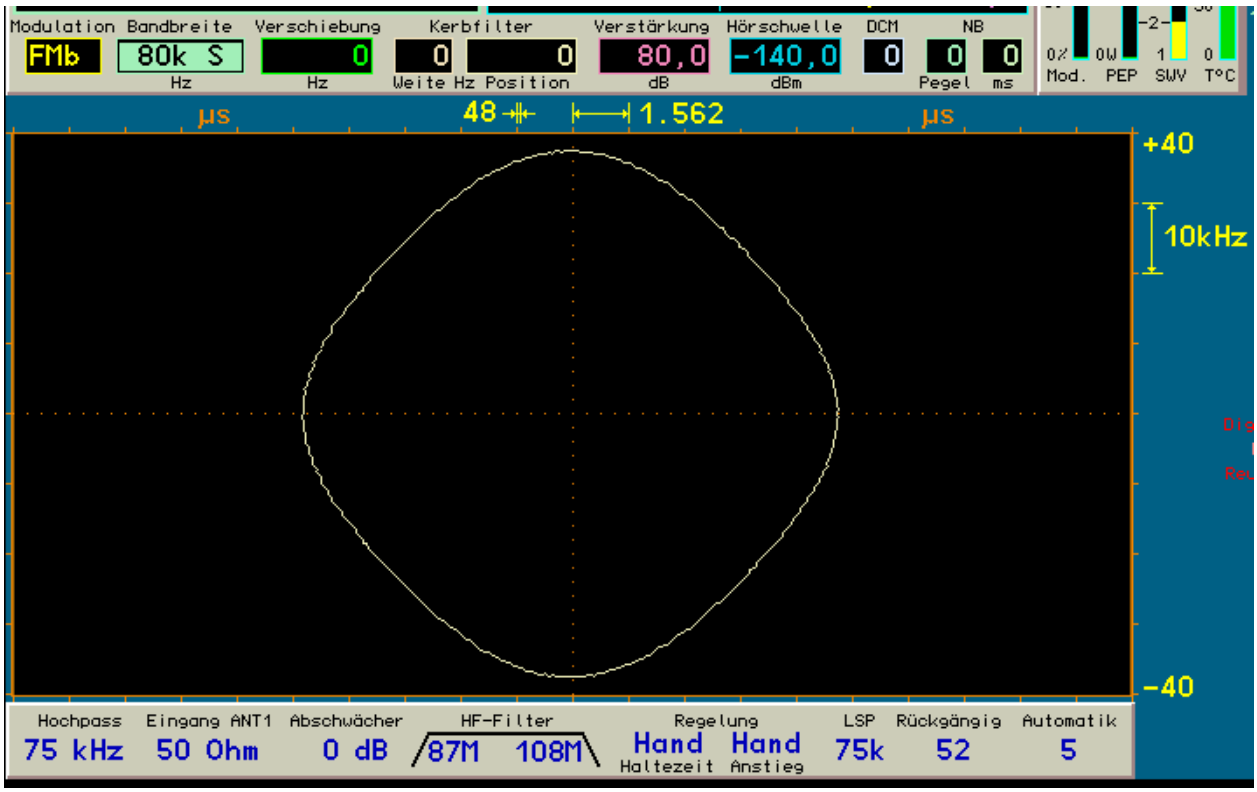
For the modulation two test signals are used: "Freq L" and "Freq R". Once they are set to a frequency greater than zero, they modulate the carrier. Up to 1 kHz a setting in 10 Hz steps is possible, beyond (up to max. 15 kHz) in 100 Hz steps. There is no pre-emphasis executed.

Note: If both signals are set to the same frequency, the test generator then generates a phase shift of exactly 90° between the two signals. In a Goniogram this appears an exact circle.

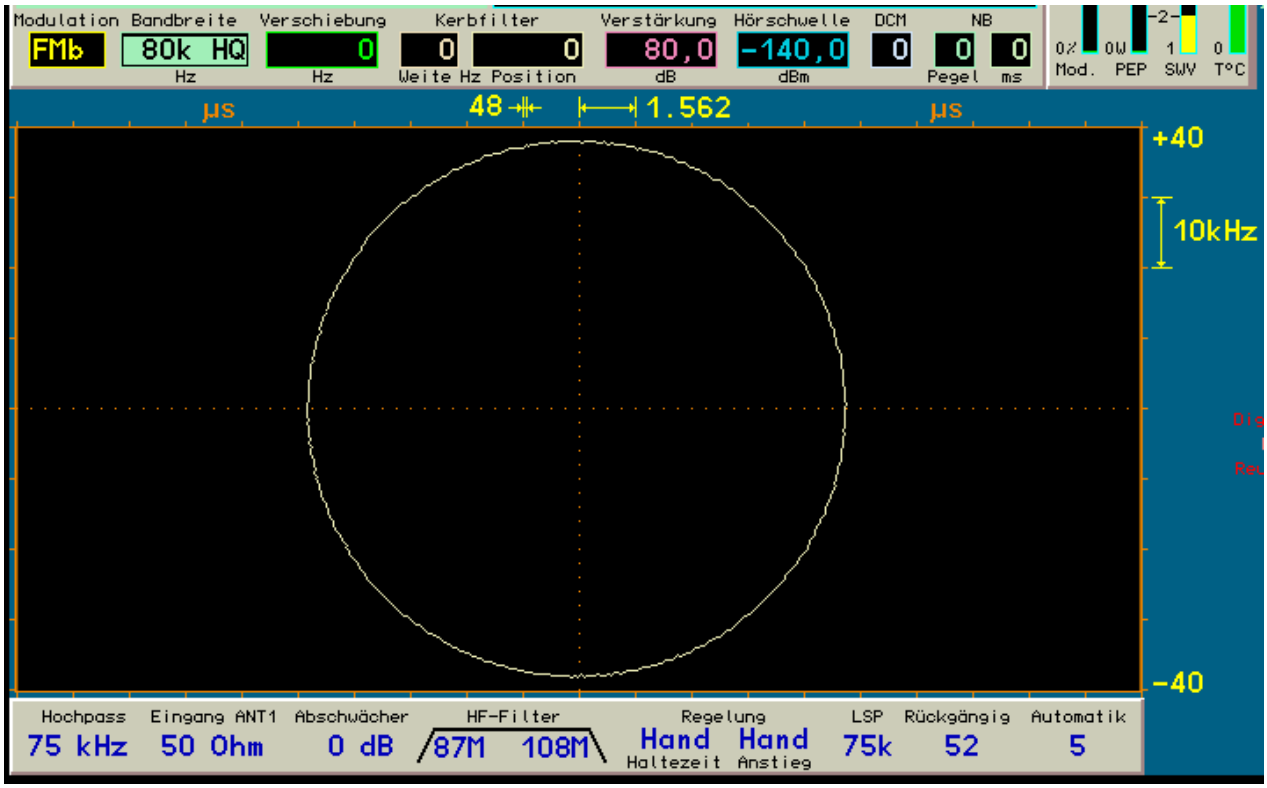
The level of the test signals is automatically always set so that the correct values are achieved for the deviation of the whole carrier according to the deviation setting. In Stereo the deviation is set to 22,5% for each test signal, in mono 50%. In stereo mode, the pilot tone is set to 10% deviation, each sideband of the difference signal with a 22.5% deviation, which is obtained for all components of a modulation of 100%.

The two test signals are pure sine waves with very low distortion (<0.001%), as well as the auxiliary signals of the stereo coder. All modulators work with min. 18-bit resolution and achieve a very high quality of the modulated FM signal.

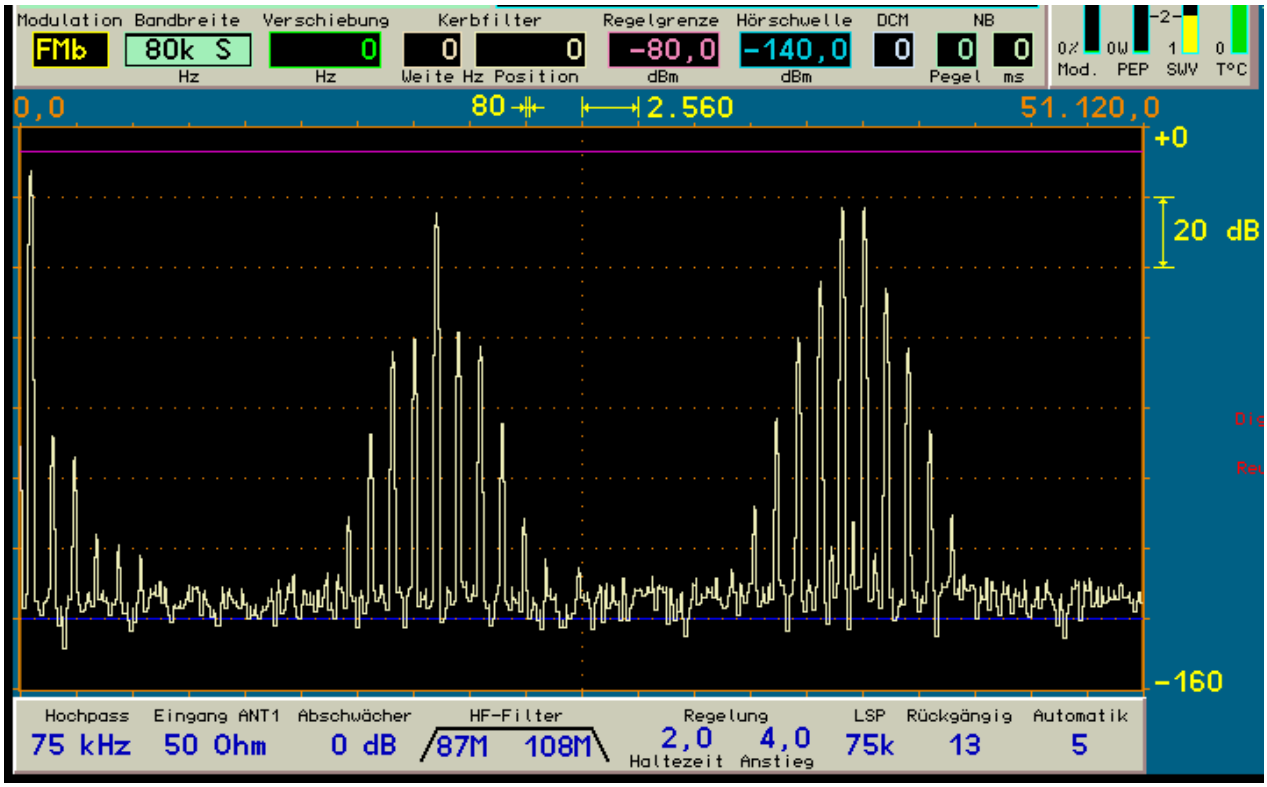
Here are some examples of different measurements with the test generator, here to illustrate the influence of various FM-W filter on the quality of the demodulated signal.



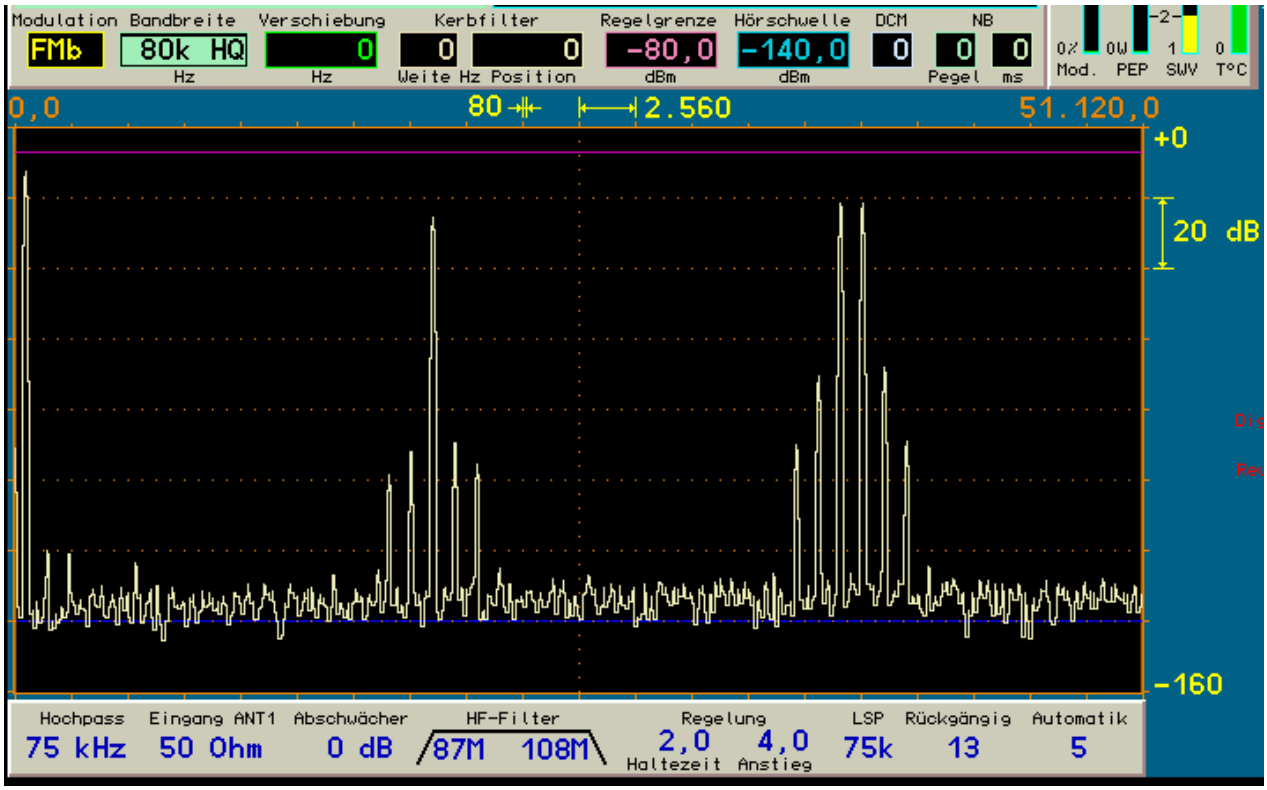
Goniogram with the same frequency for left and right channel for filter "80k S".


Modulation Bandbreite Verschiebung Kerbfilter Verstärkung Hörschwelle DCM NB
FMb 80k HQ 0 0 0 80,0 -140,0 0 0 0
Hz Hz Weite Hz Position dB dBm Pegel ms
0% 0W -2- 0
Mod. PEP 1 SWV T°C
µs 48 1.562 µs
+40
10kHz
-40
Hochpass Eingang ANT1 Abschwächer HF-Filter Regelung LSP Rückgängig Automatik
75 kHz 50 Ohm 0 dB 87M 108M Hand Hand 75k 52 5
Haltezeit Anstieg

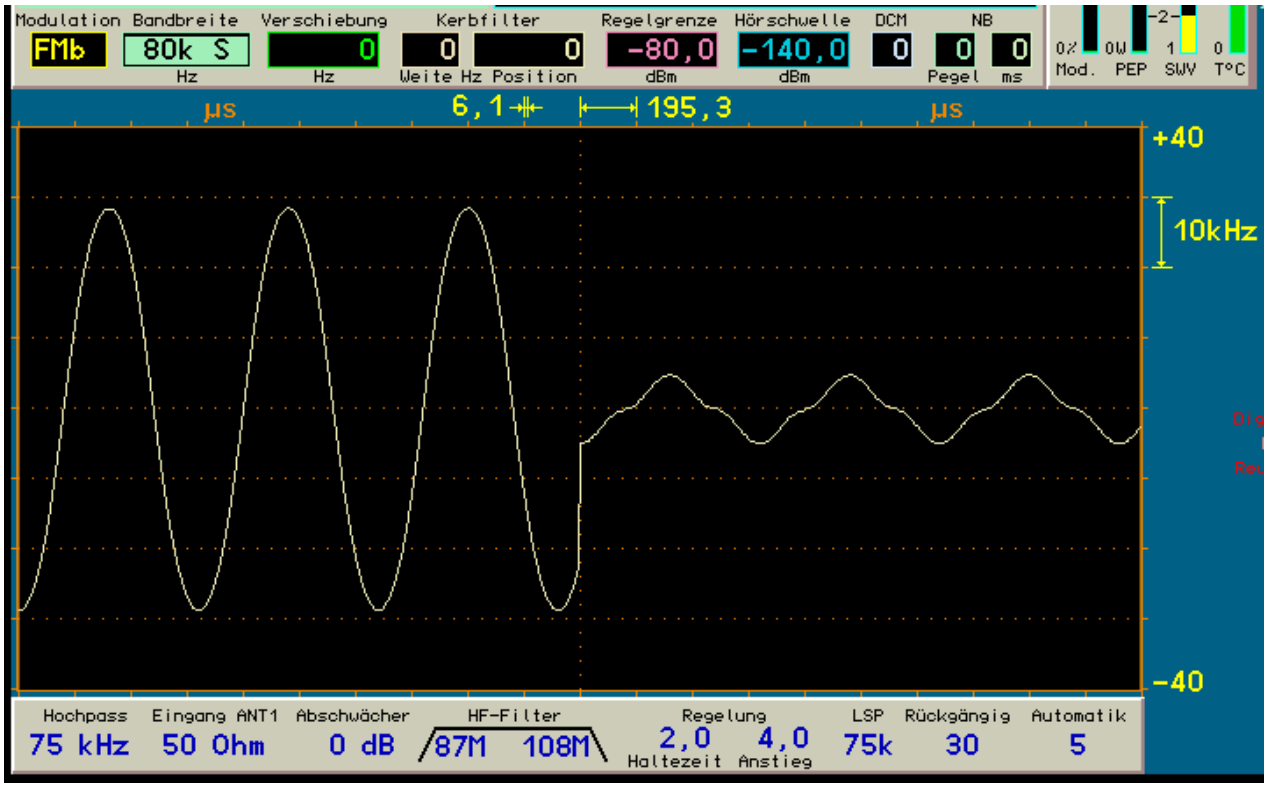
Goniogram with the same frequency for left and right channel for filter "80k HQ".


Modulation Bandbreite Verschiebung Kerbfilter Regelgrenze Hörschwelle DCM NB
FMb 80k S 0 0 0 -80,0 -140,0 0 0 0
Hz Hz Weite Hz Position dBm dBm Pegel ms
0% 0W -2- 0
Mod. PEP 1 SWV T°C
0,0 80 2.560 51.120,0
+0
20 dB
-160
Hochpass Eingang ANT1 Abschwächer HF-Filter Regelung LSP Rückgängig Automatik
75 kHz 50 Ohm 0 dB 87M 108M 2,0 4,0 75k 13 5
Haltezeit Anstieg

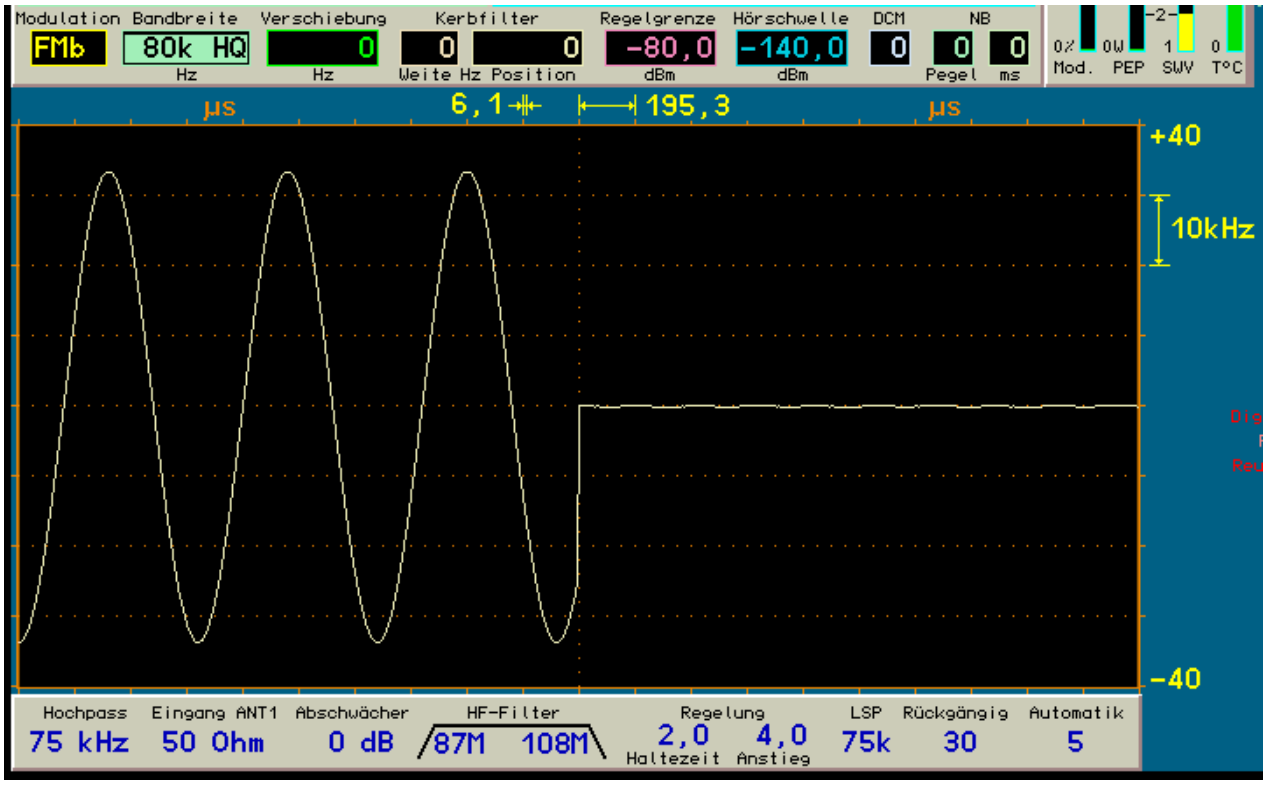
Spectrogram with the same frequency for left and right channel for filter "80k S".


Modulation Bandbreite Verschiebung Kerbfilter Regelgrenze Hörschwelle DCM NB
FMb 80k HQ 0 0 0 -80,0 -140,0 0 0 0
Hz Hz Weite Hz Position dBm dBm Pegel ms
0% 0W -2- 0
Mod. PEP 1 SWV T°C
0,0 80 2.560 51.120,0
+0
20 dB
-160
Hochpass Eingang ANT1 Abschwächer HF-Filter Regelung LSP Rückgängig Automatik
75 kHz 50 Ohm 0 dB 87M 108M 2,0 4,0 75k 13 5
Haltezeit Anstieg

Spectrogram with the same frequency for left and right channel for filter "80k HQ".


Modulation Bandbreite Verschiebung Kerbfilter Regelgrenze Hörschwelle DCM NB
FMb 80k S 0 0 0 -80,0 -140,0 0 0 0
Hz Hz Weite Hz Position dBm dBm Pegel ms
0% 0W -2- 0
Mod. PEP 1 SWV T°C
µs 6,1 195,3 µs
+40
10kHz
-40
Hochpass Eingang ANT1 Abschwächer HF-Filter Regelung LSP Rückgängig Automatik
75 kHz 50 Ohm 0 dB 87M 108M 2,0 4,0 75k 30 5
Haltezeit Anstieg

Oscillogram of a1.2 kHz signal in the left and no signal in right channels for filter "80k S".



Oscillogram of a 1.2 kHz signal in the left and no signal in the right channel for filter "80k HQ".

8.) First steps

After unpacking the receiver and carefully reading the **Operating instructions**, you can now take it into operation (note especially the Safety note!).

8.1 Unpacking and first-time operation

Please unpack the unit and set it on a hard, flat surface. The front feet are hinged to achieve a pleasant angle of operation. In case just moved the unit from a cooler in a warmer environment, let it sit for a while to avoid internal condensation. By placing a hand on the top cover or side panel, you may decide whether the unit has reached approximately ambient temperature. Remove the protective film on the display's front plate.

Check scope of delivery, as specified on the invoice and / or delivery. At least one power cable is included with the RDR54. You can use a different power cord with DIN IEC connector on one side and safety plug on the other side (eg as used in computers).

Connect (see Safety note!) the power cord. In order to receive any signal with the RDR54, you need an external antenna. Should you already have an antenna, connect it to the appropriate input jack (1 kHz - 30 MHz or 50-54 MHz etc.). Usually, you can connect your antenna using one of the supplied adapter cables from SMB to the widely used BNC standard connector. Avoid mechanical stress to the sockets! Note the maximum input level of the RDR54!

Alternatively you can use an auxiliary antenna. The easiest type of such an antenna would consist in an adapter from BNC to 4mm sockets and two lab cables/test leads with the appropriate connectors. Using them you can create an auxiliary antenna in two different configurations:

- Electrical auxiliary antenna: Plug one end of the test lead into the socket of the adapter which leads to the signal input (colored red), then the other one to the ground connection (colored black). Connect this cable to a good ground in the house, say a water or heating pipe. The other cable should be oriented straight away from the receiver, either upward or sideways. Make sure that it doesn't touch any conductive surface. You can add length using your own wiring.

- Magnetic auxiliary antenna: Plug one end of a test lead into the signal connector, the other end into the ground socket (creating a short). Hang this loop diagonally above or behind the machine on, for example on a table lamp or place it on a pile of books or the like.

Now switch on the device. The display shows the graphical interface of RDR54. In the spectrum display, signals and / or noise is shown as a continuous sequence of new spectrograms. Now you can set your machine to your liking.

8.2 Getting Started

If you already have experience in dealing with similar measurement devices or radios, operation of the device won't pose any problems. If there is anything not clear to you, refer to the corresponding chapters of this manual.

As a newcomer to the radio and / or measurement technique, we want to give you a brief introduction to the possibilities of the device that allows you to get quick results. We require the connection of the previously described auxiliary antenna or a "real" antenna.

Setting example: DCF77

DCF77 is the station identification of the time signal transmitter that controls the commercial radio clocks. Its signal has good coverage in Europe. You should be able to receive this signal with the RDR54 if you are not exactly in a very poor signal area. The connection of an auxiliary antenna as described in "Getting Started" is not sufficient in this case and you should use a good external antenna.

Start receiving DCF77 as follows:

- Tune to the frequency by selecting the reception frequency window (upper left, large bright green frequency read-out) in case it is not already active (indicated by black color on light green background). Press the main tuning knob all the way down and rotate it in the depressed state. You can see how a bright mark on the display "jumps" from window for window. Stop the rotation and release the button when the marker arrives at the main frequency window. You may need to let go the button in between and press again to continue the operation due to the rotating angle. Please note that you cannot change the input windows if you don't press the main tuning knob without pressing it at the same time! Therefore be somewhat cautious with the operation of the knob and move it slowly.

- Once the main frequency window is selected, you can change the receiving frequency by turning the knob without pushing it down. The increment of change is always displayed in F1 "grid" and can be changed by pressing F1. Turn the knob until the frequency is set to 77500.0. Alternatively, you can press "7" and start the direct frequency input of the frequency. Enter all the necessary digits one by one (the colon dot isn't necessary). End the input by pressing "F5". Pressing F1 rejects the input, pressing F2 will delete incorrectly entered numbers.

- Push the knob and move the input position to the window "modulation" (one step to the right). Change the setting after you release the button to display the "CW".

- Check to see if the parameter "notch filter / size" is set to 0. If not, move the input location to the center and set the value to 0. Do the same with the parameters "control limit" (set to 80 dB) and "RF threshold" (-140 dBm).

- When using an auxiliary antenna, you must now turn on the preamplifier. In order to do this, press "F3" and the Setup dialog appears. Select the parameter "0-30MHz Impedance (Ohm):" and set it to 0. Make sure that the parameter "Input high-pass (kHz):" is set to 1. Select it and set it also to "1". The parameter "Attenuator (dB)" should be set to 0. Close the dialog by pressing "F3". Note that on the bottom of the screen most of the parameters of the dialogue will be displayed. Check to see if the settings are correct.

- The display should now show a significantly increased signal spectrum. You can try to improve the presentation of the spectrum by pressing "F2" and set the video averaging to "Medium".

- To make the DCF77 signal better visible, the resolution of the video channel can be increased. Select the appropriate set of parameters (horizontal display width etc.) and reduce it gradually. Note that this decreases the noise level and the display speed.

- From resolutions of 20 Hz / line on the DCF77 signal can be seen in the display. It appears every second, as a "hopping" spectral line (or "line bundle" of several adjacent lines) in the middle of the spectrum. You can further optimize the representation possibly by changing the vertical (level) resolution and location by selecting the appropriate settings on the right side of the diagram. Please take note that adjustments are possible, which will cause, that nothing can be seen anymore on the screen! In this case, use the undo function according to the operator's manual instruction, or set the unit back to factory defaults.

Note: Turn on a trial basis once the waterfall display (F3 à Dialogue, "Set Up" option "Display Graphics"). Set the level position in the color table so that the precise second dots of the DCF77 signal appear clearly in a different color. Try to find a section in the "signal tracking", which clearly lacks this second pulse. This is the so-called minute pulse, once per minute indicating the expiration of the full minute.

If you do not hear the signal, reception is weak (noise must be audible, if not turn volume control to the right), you can optimize the reception as following:

- Select the value "bandwidth" and reduce it. The audible range is indicated by bright yellow coloring of the spectrum and two limiting vertical lines. The smaller the bandwidth, the less the noise and the signal has been obtained.

- Select the value "CW-tone" and set the tone frequency of the signal (always applies to the center line of the spectrum) to a value that contrasts well with the noise and the ambient noise.

- Try if a better intelligibility of the signal can be achieved by by increasing the value of "DNR" (noise reduction system). It is usually set to “0”.

- Vary the control limit in such a way that is up regulated in low signal far enough (automatic) and the gain is high enough (for manual control). The upper, horizontal purple line on the display always shows the current gain and headroom. Signals should reach but not exceed this line.

- Vary the threshold so that noise and unwanted signals are below the blue line. For CW signals, a noise-free reception is achieved when the desired signal exceeds the threshold and just not all the others.

After you have successfully carried out the above settings, you can now go to "wave hunting"! Simply select the desired demodulation (bandwidth and PBT-Shift will be pre-set with every change) and be careful to chose an optimal setting for the AGC control. At high span rate of the spectrum (160 or 320 Hz / line), you can look at all receivable signals while "cranking" the frequency. Stations within the yellow lines can be heard.

Please check in each section of the manual about other settings such as step width adjustment, special function key 0 storage system and undo ... to increase operating efficiency and to avoid prolonged rotation movements of the knob.

8.3 Common settings for radio reception

After you have learned the basic operation and control philosophy of RDR54 know, you can use specific features to exploit the maximum capability of the device. Here are some tips and setting examples.

AM radio reception

For the reception of broadcast channels in the Long, Medium and Shortwave bands set the parameters of the level control to "Automatic" (dialog "Setup" by pressing the "F3") and the demodulator to “SYNC”. In this mode, the two-sideband amplitude modulation of the common radio station is always at the correct frequency, no matter where you find the signal in the spectrum display. The detection is done by the so-called carrier signal, which is shown in the display as a permanent narrow line, which is of more or less surrounded by the strongly varying information content (voice or music) (see illustration in "Introduction").

To search for a broadcaster is it best to use the maximum display width of the spectrogram (10.28 kHz / DIV). Useful is the maximum value filtering of the video signal with a very short refresh time, ie about 0 - 50 ms. Thus, the striking "silhouette" of the radio stations with their carrier peak and the surrounding modulation is easily recognizable. Adjust the vertical position of the chart so that the noise line is a few ticks above the lower limit, and the vertical resolution is set to 10 - 20 dB / division.

You can now set the frequency to the lower frequency of a known radio band, for example, 500 kHz for the Medium wave band. Select in the step size window (by pressing "F1") a value slightly below the width of the span, such as 100 kHz. You can now easily scan the entire band by indexing the receiving frequency with the main tuning knob. The high display speed of the spectrum display allows the immediate interpretation of the signal spectrum in real time.

Optimize now the reception of the station that you want to hear. Change the grid step to smaller values (eg 1 kHz) and tune the receiver so that the station is located in the center of the spectrogram. Use the bandwidth and the shift-adjustment so that no signals of adjacent channels are audible. Hets can be eliminated with the Notch filter. Initially set it to a width of appr. 200 (Hz) and shift it to the position in the spectrum that shows the Het line. Vary the size and position so that only the Het gets suppressed and as little as possible from the transmitter signal is cut out.

Often you can not eliminate all the problems or the transmitter is very weak and you will also hear loud noise.

Here are some tips to receive further optimization:

- Try optimizing the setting of the gain control (AGC rise and hold time).

- With sufficient signal strength, you can use the lower marker to block out some noise. Here, the broadband noise starts first clanking and ringing (similar to bird chirping) then disappears when it is no longer able to pass through the marker line. Of course some signal components of the transmitter modulation will be

suppressed, the ones which do not extend beyond this line. In some cases, however, an improvement in speech intelligibility can be achieved.

- Use the noise reduction system, by switching the setting "DNR" tentatively above 0. The effect depends strongly on the signal. Set "DNR" depending on taste and try of a specific setting leads to a better reception. The steps 10-19 and 30-39 contain an algorithm for detecting the side bands, they only generate audio frequencies for which there are signals in both sidebands (suppression of adjacent stations or discrete interference signals in one side band).

- Use the high-frequency filter, the pre-amplifier or attenuator and the input high pass. Should strong interfering signals exist at the antenna input you can possibly compensate this by selecting an RF filter. You can reduce noise by choosing a filter that attenuates the frequency more than your listening frequency. Imagine the direction in which the interferer is located ("down" or "up") and if a high-pass (interferer is at a lower frequency) or lowpass filter (interferer is at a higher frequency) will attenuate the interference better. Accept in this case an attenuation of the wanted signal, as long as it is not deteriorated by the fundamental instrument noise (at 20 Hz / line around -120 dBm).

- Use the demodulator setting "DSB" and set the carrier of the signal exactly (maybe choose very fine step size) to the center line of the spectrum one. In this setting the carrier fluctuations have no effect on the demodulation. But you need to turn off or configure the system fundamentally different (see "SSB reception"). You can also use the USB or LSB demodulator, if you want to receive only one sideband.

- Use the special setting "Surround sound" and a stereo headphone or amplifier.

- In case of a very good reception, the "AM-H" demodulator with its much lower level of distortion can be used. It sounds “tube-like”.

SSB reception

For reception of SSB (= single side band) signals set the demodulator to "LSB" (= lower side band) or "USB" (= upper side band). If you use the demodulator "SBCW" the RDR54 will switch from LSB to USB automatically as soon as the 10 MHz limit is reached.

Proceed in principle as in the reception of broadcast stations. SSB transmitters emit no continuous carrier signal, thus their identification is difficult. However, in main activity areas (such as ham radio bands) they are determined very accurately. Adjust the reception range accordingly - possibly increase the resolution of the spectrogram to represent only the region of interest. Increase the sampling rate of the maximum value filter to the point that short-term signals are displayed for a short while. In extreme cases, you can use the setting "infinite” which will freeze in the display image until the frequency will be changed.

If you want to use the automatic control choose a long delay time, roughly corresponding to the longest expected interval modulation. The speed control can be adjusted to the reception conditions (fading).

CW reception

The reception of Morse code is possible in the demodulator setting "CW" (= continuous wave). Choose a resolution that fits the keyer’s speed and shift the signal into the audible range (a little away from the “carrier”, say 500Hz). Limit the listening area with the bandwidth control so that in extreme cases only 2 or 3 spectral lines "bandwidth" are for the left signal. This will improve intelligibility dramatically.

Note: The line width can not be compared directly with usual analog equipment giving a filter bandwidth. For a rough comparison calculate the "receive bandwidth" of the RDR54 as width of line times the number of "audible" lines plus 2 times the line width.

Example:

Resolution 10 Hz / line x 2 (yellow lines) + 2 x 10 Hz = 40 Hz

Essential for the detectability of the signal time are the internal delays ("transient") of the RDR54. A signal jump is accurately represented by a time duration corresponding to the reciprocal value of a quarter of the line width.

Example:

Line width 10 Hz / 4 = 2.5 Hz à 400 ms maximum settling time.

In practical terms, this value is about half as large because the signal processing operates strictly linear phase without any overshoot.

Note the possibility of "noise-free" reception keyed modulation, as described in Example DCF77 reception.

The pitch of the generated NF-tone for a CW signal can be set directly on the center line of the spectrum using the set value "CW-tone".

9. Troubleshooting

The variety of device capabilities, some multi-function key assignments and the possibility / necessity of the limitation of setting procedures could lead - at least during the training period – to difficult to understand operating conditions. Below you will find some information to the most common questions.

I don’t see anything (on the spectrum display)!

Normally, in the spectrum graph a "moving" trace is shown, without a connected signal source at least the intrinsic noise of the device. In case a curve cannot be seen (in fact, the curve is a straight line directly to the upper or lower limit of the diagram), the settings for the level scaling at large distances do not correspond to the actually existing levels on all inputs. If only the average noise curve can be seen although you expect a signal, there is something wrong with the input circuit or the RF filters. Check the device setting as follows:

- Is anything connected to the antenna input, which is suited for the momentarily selected main reception area (Ant1: 0 - 30 MHz, Ant2: 50 - 54 MHz, Ant3 88-108 MHz)?
- Are the RF filters turned on manually (not on "Auto" or "Off") and limit the reception area?
- Did you activate the attenuator or the input high pass filter, even though you want to receive very weak signals or signals in the range below 75 kHz?
- Is the resolution level set to very small values (eg 2 or 4 dB / DIV)?
- Is the level location set to extreme values (eg> 20 or <-60 dBm for the upper range limit)?

I can’t hear anything!

At least the intrinsic device noise can always be heard via the built-in loudspeaker. In case this is not the case check the following settings:

- Turn the volume control several steps to the right (clockwise) without pressing to adjust the speaker volume and then while pressing to increase the headphone volume.
- Is the speaker activated in the setup dialog?
- Is the top line marker too far from the highest level of the spectrum curve (gain set too low)?
- Are both vertical markers set too close to another (audible range set to practically zero)?
- Does the notch filter cover the entire area between the vertical markers thus blending out the audible range?
- Did you select the Auto-Demodulator (“SYNC”) but want to make a CW signal audible (this results in 0 Hz audio frequency)?
- Is an external speaker connected correctly?
- Are headphones connected correctly?

This button does not do what they want!

The buttons have multiple functions and sometimes react differently depending on the operating condition of the equipment, sometimes they are simply locked completely. Check the device status as follows:

- Did you start the direct input with a value which was not allowed (e.g., frequency scaling of the graph)?
- Did you start the direct input with the digit 0 (impossible)?
- Did you start the direct command with a colon or a minus sign, although the specific value doesn’t allow or support this?
- Did you happen to press "F1" (= discard), although you wanted to press “F5” (=okay)?
- Did you enter a value directly and it was not accepted by the receiver? Did the receiver limit the value to the appropriate one?
- A function key does not respond in the expected way. Check the actual inscription of the function key . You can shift the current entry mark to the desired function and then change the function key.

Closing a dialogue RDR54 falls into an unexpected state!

- Did you select a memory call or a memory setting in the Undo dialog and closed the dialog with "F5"? In this

case the device settings are updated completely with the stored values. If this is not what you wanted, open the dialog again, select the parameter "Undo operation No.:" and select one value lower (previous) than the currently indicated one. If “1” is displayed chose “63”. Close the dialogue with “F5” and your receiver is back in the exact stage it was before you made changes that led to the unexpected condition.

- Did you chose in the setup dialog an extreme or impossible value (for example, a very low brightness)? In this case, open the dialog with "F3" again and check the values. If the brightness is set to "0" you will see nothing on the display. In order to correct this, turn the power off and back on ("ON / OFF"), which brings back the display with a minimum brightness. Adjust accordingly.

I can not change this value!

For all values certain lower and upper limits exist. You cannot enter extreme values, either directly (limited automatically when pressing "F5"), nor change the limit beyond reach by turning the main knob. But even within the rather wide range of possible values, there are limitations due to mutual dependencies. Note the current instrument setting and your wanted values as follows:

The frequency cannot be shifted.

- Is the increment of the frequency (synonymous with "grid" for the labelling key "F1") set so wide that an adjustment would exceed the range limits?
- Is the RF filter off or not set to automatic operation? An exchange between the range 0 - 30 MHz and 50 - 54 MHz is not possible. Turn to the first filter before you want to move the reception area to the desired frequency range.

The notch filter cannot be shifted.

- Does the notch filter fill already the entire audible range? Is its width equal to or greater than the difference between the two vertical markers?
- Does the wanted position of the notch filter exceed a vertical line marker?

A marker can not be moved.

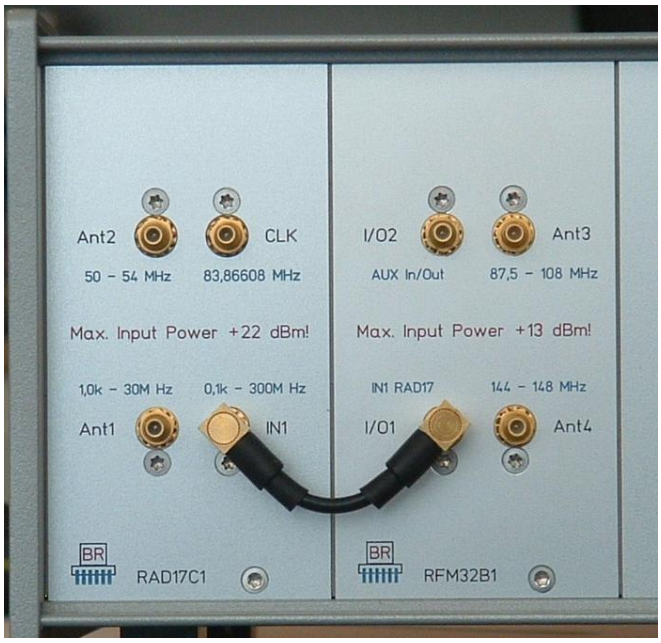
- The lower marker can never be positioned on or above the upper marker and vice versa.
- The lower marker is in automatic control never equal to or higher than the control limit (upper set point markers).
- In case the upper marker is turned on in the automatic control, it can never be manually positioned below the highest value of the audible spectrum curve. In this case, the value of the marker specifies how far down the automatic can position the marker maximally.

10.) FM module RFM32

For the reception of the frequency range 87.5 MHz - 108 MHz (FM radio) and 144 MHz - 148 MHz (2 m amateur radio band), the module "RFM32 ' is needed.

10.1 Hardware

The module can be installed on the rear panel of the RDR54. In order to do this, remove the blank small panel and insert the module into an available slot. The positioning right next to the ADC module is optimal. The input IN1 of the ADC module and the I/O1 output must be connected with a short SMB cable. To close the enclosure, a new blank front panel of appropriate width should be used.



RFM32 module connected to the ADC module RAD17

On the antenna inputs ANT3 ANT4 antennas for 2m and FM can be connected. The maximum allowable input level of +13dBm must not be exceeded!

The antenna inputs are protected to some extent against electrostatic charges, but are not suited as lightning protection. Professional devices are required for that.

The outputs I/O1 and I/O2 are directly connected in parallel. Here either the amplified reception signal of the RFM32 can be tapped via the high impedance output or a low frequency measurement signal (audio) can be looped into the ADC. The internal circuitry of the module RFM32 is coupled via an 80 MHz highpass filter to I/O1 and I/O2.

10.2 Software

The module RFM32 contains the necessary software for controlling the internal units, the tracking filter for ANT 3 and switching of ANT3 / ANT4 depending on the frequency range. The software works with the operating system and is updateable at any time with the RDR54's boot loader.

In both frequency ranges all FM modulation modes and other settings such as in the short wave band or 6 m are available. Thus, for example, in the 2 m band in addition to narrow-band FM ("FMs"), SSB or CW can be received if wanted.

Note: Left and right channel of the demodulated stereo signal can be fed via the head-phone jack in 16 bit quality into a HighEnd audio amplifier.

10.3 Technical data RFM32

Frequency range (ANT3):	87.5000 ... 108.0000 MHz (± 3 dB)
Frequency range (ANT4):	144.0000 ... 148.0000 MHz (+1 -2 dB)
Passage gain:	nominally 27 dB
Noise factor:	<= 2 dB
Intermodulation IP3 intersection:	about +10 dBm
Maximum input level:	+13 dBm
Input impedance:	50 ohms
Input return loss:	> = 6 dB (in the frequency domain)
Output return loss:	> = 30 dB (above 87.5 MHz)
1 dB compression point:	about -6 dB
" in conjunction with RAD17C:	approximately -26 dBm (ADC clipping)
Alias Attenuation 87.5 MHz - 108 MHz:	> = 60 dB, falling from 91 MHz to 87.5 MHz at 35 dB
Alias attenuation 144 MHz - 148 MHz:	> = 80 dB

The RFM32 module contains "only" filter and amplifier for each frequency range. It doesn't use ANY frequency conversion (oscillator + mixer or similar). The amplified signal is directly converted by the ADC and digitally processed. This is possible despite the low CLK frequency of 83.886 MHz by taking advantage of the aliasing effect.

All amplifier stages are equipped with modern e-pHEMT GaAs transistors. The band-pass filtering is performed in each range with 3-stage intermediate amplifier / impedance matching devices. In the 2 m band all the filters are tuned small-band, in the 3 m broadcast band two filters are tuned and the matching filter are designed as broadband types. The tuning is done by switching high quality capacitors (microwave ceramic types) using opto-isolated GaAs power switches. Only that way, the low amplifier distortion can be guaranteed and a significant reduction of the IP3 value can be avoided.

A continuous 100 dB attenuation of spurious signals of the RDR54 can not be achieved in the FM band. Especially at the beginning of the FM broadcast band, the attenuation of alias frequencies is decreased (image frequency in relation to the clock frequency = 2 * 83.886 MHz - receive frequency) due to the close proximity of the reception frequency to the clock frequency. If a strong jamming station appears at the aliasing frequency to the reception frequency (in the range 76 - 80 MHz), external filters (traps / notch filters ...) must be provided.

11.) Transmitter module RPA5

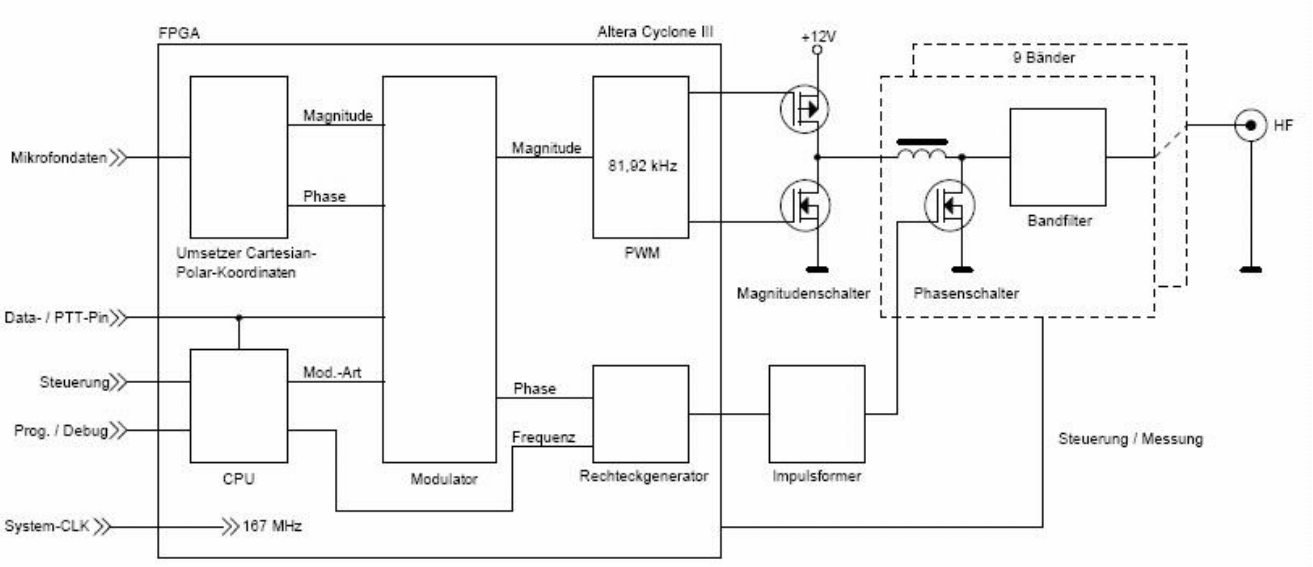
The measuring and communications receiver RDR54 can be upgraded with the RPA5C module to be used as a transceiver. This module contains a complete channel for the 9 amateur bands ranging from 160 m to 10 m, including a power amplifier with a maximum output power (PEP) of 5 W. The module only works in the RDR54 if the audio module FDA20E is also installed.

11.1 Overview

The transmitter module in RPA5 works as well as the receiver module RDR25 fully digitally using fundamentally new operating principles. While these provide the recipient with a newly developed time-frequency transformation without FFT for outstanding reception in the receiver, the principle of the polar coordinate modulation is used in the transmitter.

Seen just for the power amplifier (PA), this corresponds to the familiar "envelope" method. Here, a Class C or E / F amplifier is operating (not linear) with a modulated power supply, where the current peak corresponds to the envelope of the generated signal. The amplifier must be phase modulated. An output filter suppresses the harmonics of the nonlinear amplifier. The necessary signals for the modulation of the supply voltage and the phase modulation of the amplifier are extracted in other devices from an analog signal (SDR conventional transmitter or transmitter with digital to analog converter).

In the RPA5C module the generation and modulation of all signals is done in principle at the level of the phase and magnitude information (polar coordinates). Therefore, all the signals required for the power amplifiers are available from the beginning, thus no D / A converter is necessary. The signals have a high accuracy, thus allowing very good properties of modulation and signal quality of the high-frequency transmission signal.



Block diagram of polar transmitter

The statement that "no D / A converter" is used is not entirely accurate. Ultimately, however, a sinusoidal, analog transmit signal with the respective modulation is generated. The transformation of the rectangular, digital control signals into the analog transmission signal is done at polar transmitter but not by a semiconductor device with subsequent amplification. Rather, the powerful high-frequency oscillation occurs directly inside the reactance of the output filter. Here a relatively high reactive power oscillates, controlled by phase and magnitude switches whose filtered-out real part (with some reactive component, depending on the alignment) creates the analog transmission signal.

The magnitude switch for the modulation of the envelope is present only once, while there are separate phase switches and output filters for each band. However, 17 m and 15 m band, and 12 m and 10 m band share one waveform with another. The band switching or release of the modulation is done electronically at the sender

without the use of a relay.

The exception is a static relay switching for the bands above 10 MHz (always when they are reached in the tuning), because the lower and upper bands are arranged on two different boards.

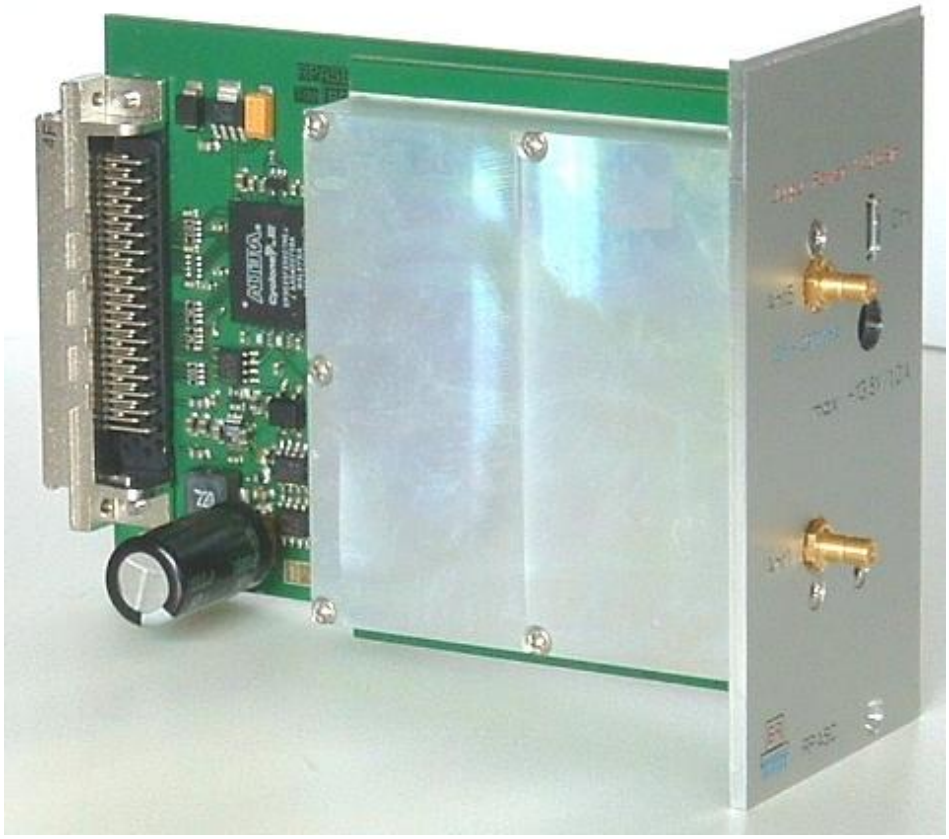
For the achievable signal quality the properties of the switch and filter components and the accuracy of the control signals are of crucial importance. Here are some examples of the resolution obtained with regard to bit-width and frequency / time resolution:

- Magnitude and phase: 18-bit with kSps 81.92
- PWM Clock: 334 MHz + DDR (=double data rate) -> 13 bit resolution, 1.5 ns accuracy of the control signals of the magnitude switch
- Square wave generator frequency setting: 0.625 Hz resolution, 6 ns time resolution of the flanks
- Pulse shaper: increasing the time resolution for both flanks to 10 ps accuracy of the control signal for the phase switch
- Phase switch: ZVS switch (=zero voltage switching) for up to 100 VA reactive power.

The highly accurate and jitter-free adjustment of both flanks of the control pulse of the phase switch is essential for the CW quality of the generated signal. The achieved 10 ps correspond at a 40ns signal period approximately a resolution of 12 bits. The quality of the output signal resembles the one coming from a DDS generators with similar DAC resolution, their spurious and noise spectrum are quite similar.

The characteristics of analog components, including the switches and the accurate reproduction of the envelope are critical factors for the resulting intermodulation products in AM, SSB and DSB.

Another great advantage of the "polar method" is the high efficiency (active elements are only needed during switching). Thus, the very compact module requires no additional cooling and heats up only slowly. It reaches somewhat higher temperatures only at and continuous CW use.



The complete transmitter module RPA5C.

11.2 Technical data

Frequency ranges:

160 m-band:	1.81 ... 2.0 MHz
80 m-band:	3.5 ... 3.8 MHz
40 m-band:	7.0 ... 7.2 MHz
30 m-band:	10.1 ... 10.15 MHz
20 m-band:	14.0 ... 14.35 MHz
17 m-band:	18.068 ... 18.168 MHz
15 m-band:	21.0 ... 21.45 MHz
12 m band:	24,89 ... 24.99 MHz
10 m-band:	28.0 ... 29.7 MHz

Power output (into 50 ohms, PEP):	30 ... 37 dBm ± 1.5 db
Efficiency:	> 0.6
VSWR (into 50 ohms real):	<= 1.5
Upper / secondary wave attenuation to 50 MHz:	> 50 dB
Upper / secondary wave attenuation from 50 MHz:	> 60 dB
Intermodulation third and higher order: (fmod 1.0 kHz + 1.5 kHz)	> 40 dB (5 W PEP)
Modulation types:	AM, DSB, SSB, CW, FM-N, FM-W
Modulation bandwidth	0.07 ... 9.6 kHz, depending on the mode
Rise / fall time of RF signal (CW / FM):	0.1 ... 9.9 ms selectable
Delay PTT / Button à RF Out:	2 ... 255 ms adjustable
OFF PTT / Button à RF Out:	<2ms
PTT muting delay / off button à RX:	0 ... 630 ms adjustable
Shift TX / RX frequency:	0 ... ± 9,999,999 Hz adjustable (1 Hz)
VOX holding time:	OFF, 10 ms, 250 ms, 500 ms ... 2500 ms adjustable
Squelch / Anti-VOX:	From -82, ... -34 dB adjustable
ALC:	0 (off) ... 100% action set
Damping ANT5 à Ant1 (for RX, within the bands):	1.5 ± 1 dB
Damping ANT5 à Ant1 (at RX, outside the bands):	max. 6 dB
Damping ANT5 à Ant1 (at TX):	> 60 dB

Special features:

- Adjustment option for maximum SFDR (Spurious Free Dynamic Range)
- Adjustment option for minimal IM
- CW keying possible with VOX (setting 10 ms)
- Combined SSB / CW (SBCW) with the possibility of sending CW in SSB sideband
- Adjustable Frequency Deviation for FM-N separately and FM-W
- Two-tone test generator with adjustable frequency and level
- Modulation / power / SWR and temperature measurement
- Transmit / receive switch on the TX output
- Internal (up to max. 34 dB PEP) or external (+13.8 V, ± 5%) power supply
- Protection circuits against over current, over temperature (> 70 ° C), PEP > 7 W, SWV > 10
- Switching output 5V logic for band (BCD) and TX-ON
- Phantom power, EQ and adjustable side-tone for microphone channel

11.3 Operation

For the controlling of the transmitter an extended user interface is necessary. It includes the setting and display functions for the transmit mode. These are the configuration of the microphone input and the temporal sequences of the transmit-receive switch, and the indicating transmitter-relevant parameters such as power, SWV, modulation or temperature of the output stage. Furthermore, a detailed analysis of the microphone signal and the transmitted signal and the adjustment of the transmitter for the best possible signal quality is possible.

The transmit operation is only possible with the user interface "radio" from version 210 on. As soon the module is installed, the RPA5 control window appears to the right of the panel of the instrument setting (upper part of the display) as a small panel with the status LEDs of the transmitter.

Display panel of the transmitter

The right side of the transmitter panel turns red when the transmitter is activated, in case of errors the entire panel turns red. The controls have the following functions:

- "Mod": modulation level in %. This indicator shows the momentary modulation voltage from the microphone input of the module FDA20E. It is always active, regardless of whether the transmitter is working or not. Thus a permanent control of the microphone setting and its operation is possible. The bar turns from green to red when the modulation level reaches 100% (limit of the signal).

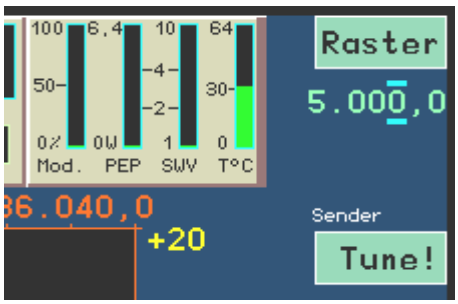
- "PEP": peak power output in watts. Measured over a period of 0.8 s it shows the maximum amplitude of the RF output power. The bar indicator turns yellow when the permissible performance without external power (+34 dBm = 2.5 W) is exceeded. It will turn red if the nominal output power of +37 dBm is exceeded (5 W). In case the indicator exceeds the value of 6.5 W, the transmitter will be shut-down in emergency mode. The display always shows the current status with a 0.8 s delay.

- "SWV" standing wave ratio. This bar chart shows permanently the last measurement of the value of standing wave ratio. A measurement and updating of the display is triggered each time the output power reaches of > 0 dBm (0.6 s is the measuring rate in case the output power > 0 dBm). If the SWR is larger than 2, the display will turn to yellow. From a SWR of 10 on the bar turns red and the receiver performs an emergency shutdown.

- "T ° C": temperature of the RPA5 module. Shown is the highest temperature of the module's board. All power elements are surface mounted (SMD), the board temperature is therefore a relatively accurate measurement of the temperature of the components. From 55 ° C (130F) on, the display will turn yellow and red at 64 ° C (147F). In case the temperature exceeds 70 ° C (158F), the transmitter will perform an emergency shutdown.

The transmitter can be switched on only by PTT / KEY button,VOX or TUNE, in case its frequency lies within the specified frequency bands. The signals from the PTT, KEY and VOX are generated by the connected switches or the VOX function of the FDA20 module. The signal TUNE can be generated by pressing F2 in case the active user interface setting function is "frequency" (double occupancy):

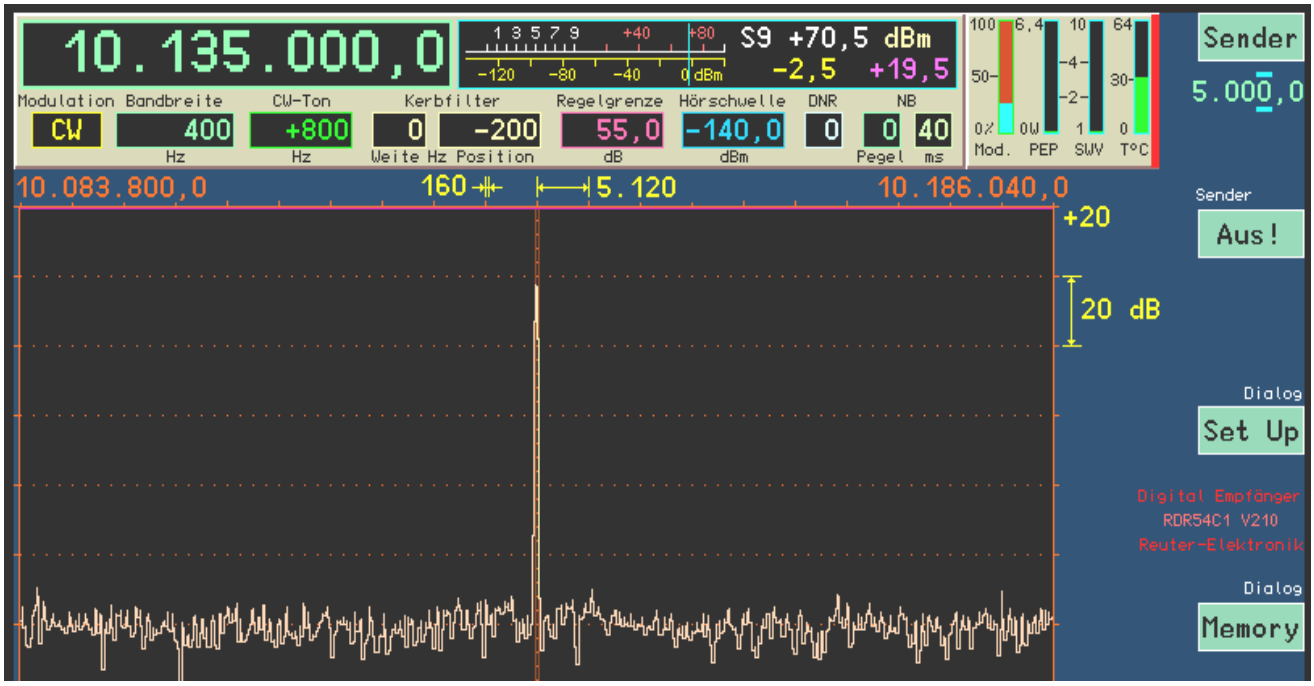
- F2 (normal = Video filters), here **for active frequency tuning** Function = "Tune".



By pressing “F2“ the tuning function is activated. The transmitter will be switched on with 0% modulation and minimum power. It generates a CW carrier at the set frequency.

<u>Attention!</u> If the test generator is activated, a carrier with 25% of the transmitter set power will be created in the AM mode immediately. In modes without generating a carrier, a signal will be created with the test frequencies as modulating frequencies.

The active function changes from the frequency to the bar graph of the modulation (inversion of the colors). This indicator is now used to adjust the transmit power or modulation level when the test generator is active. The transmit power can be varied; the modulation display shows the set value from 0% (minimum possible power) to 100% (according to power setting in the transmitter dialog). As long as the tuning function is active, no other setting can be chosen, other than the dialogue window. “F2” closes the tuning function again and the unit returns to normal operation.



Activated "Tune" function

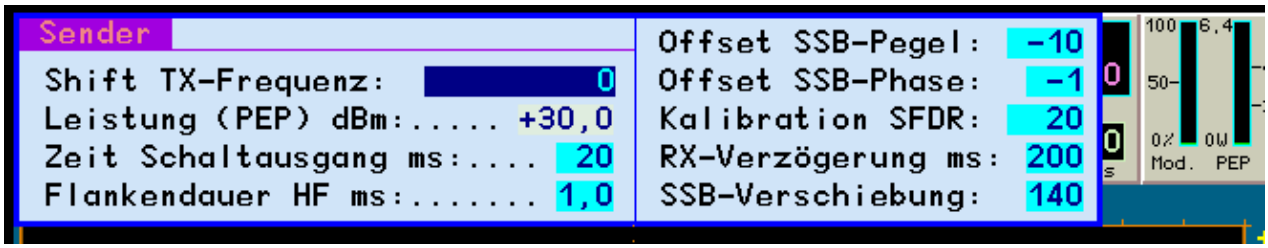
In addition to the double occupancy of the F2 key to enable the function “Tune!”, the F1 and F5 keys also have a dual function.

- F1: Step width setting of the frequency at **active frequency tuning**, opens dialogue "Transmitter" at **all other active settings**.

- F5: Surround sound switch **at active frequency tuning**, opens dialogue "Microphone" at **all other active settings**.

Dialogs are available to configure both the microphone input and transmitter operation within wide limits.

Both dialogs are integrated with the spectrum display and the transmitter display panel, making precise control of settings possible.



Configuration of the transmitter settings

“F1” opens the transmitter dialog (frequency tuning INACTIVE). The parameters have the following meanings:

- "Shift TX-Frequency:" Difference of the set frequency relative to reception frequency (center frequency of the user interface) with positive or negative values to ± 9,999,999 Hz, the transmitter can be turned on only if the main frequency ± the TX frequency is within the permitted ranges. The TX frequency is always changed with the main frequency. In case the frequency is outside the valid ranges, the transmitter will be turned off.

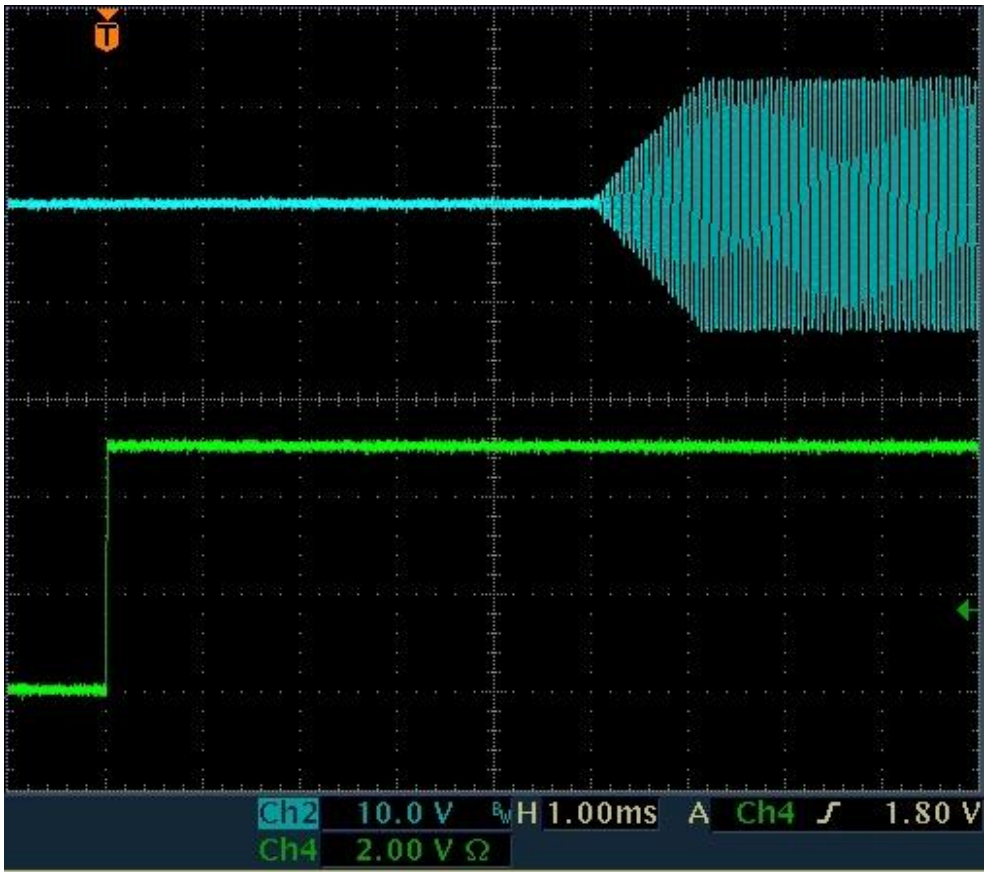
  Note: The adjustment of the TX frequency happens always with the same step size which is selected in the user interface for the main frequency. Similarly, the "0" button has again the function of rounding to integer frequencies corresponding to the increment.

- "Power (PEP) dBm:" Setting the output power of the transmitter. In the case of internal supply a maximum of +34 dBm can be achieved, with external supply up to +37 dBm. The minimum is +30 dBm.

  Attention! Without external power supply, the transmitter can shout down without prior warning!

- "Timer output ms:" The TX-ON-switching output (pin 1 of connector "Ctrl") is immediately active with PTT. The RF power is generated only after the time set here (allowing RX / TX switching of external PAs).

  Example in the picture below: PTT switching time à RF = 5 ms (Rise to 1 ms):



Note: There is no "switching off" delay. The output is switched off after the end of the transmission including its slope as soon as possible (within max. 2 ms).

- "Edge length HF:" Rise / fall time of the RF power to enable / disable the transmitter (see picture above with edge time = 1 ms). Increase or decrease the power are strictly linear with no overshooting of any kind. In AM modulation (carrier on / off) or at an emergency shutdown of the transmitter the edges can be reduced to zero and overshoots can occur.

- "Offset SSB level" adjustment option of the modulator for minimal IM.

- "Offset SSB-phase" matching ability of the modulator for minimal IM.

Note: The signal quality in terms of IM headroom is dependent on frequency, modulation and manufacturing tolerances of the transmitter's components. The two offset adjustment possibilities allow a specific setting for one specific operating point of the transmitter, wherein a maximum IM headroom is possible. At "good" frequencies, an improvement of up to 20 dB compared to the guaranteed 40 dB (PEP) can be achieved.

- "Calibration SFDR:" Adjustment to the largest spurious suppression. This setting is mostly unit dependent and only slightly temperature dependent in terms spurious attenuation of the transmitted signal.

  The adjustment should be performed at normal operating temperature and high frequency (after warm-up). A good frequency is 29.18 MHz, for example. At full spectrum width (320 Hz / line) two interfering frequencies are shown on the right and left side of the carrier. These can be adjusted to minimum.

  Note: When updating the software, or when loading the default settings (dialog "Memory," Undo operation # 0), the calibration will be lost. However, they are always stored with a memory position, so they can easily restored from any memory position.

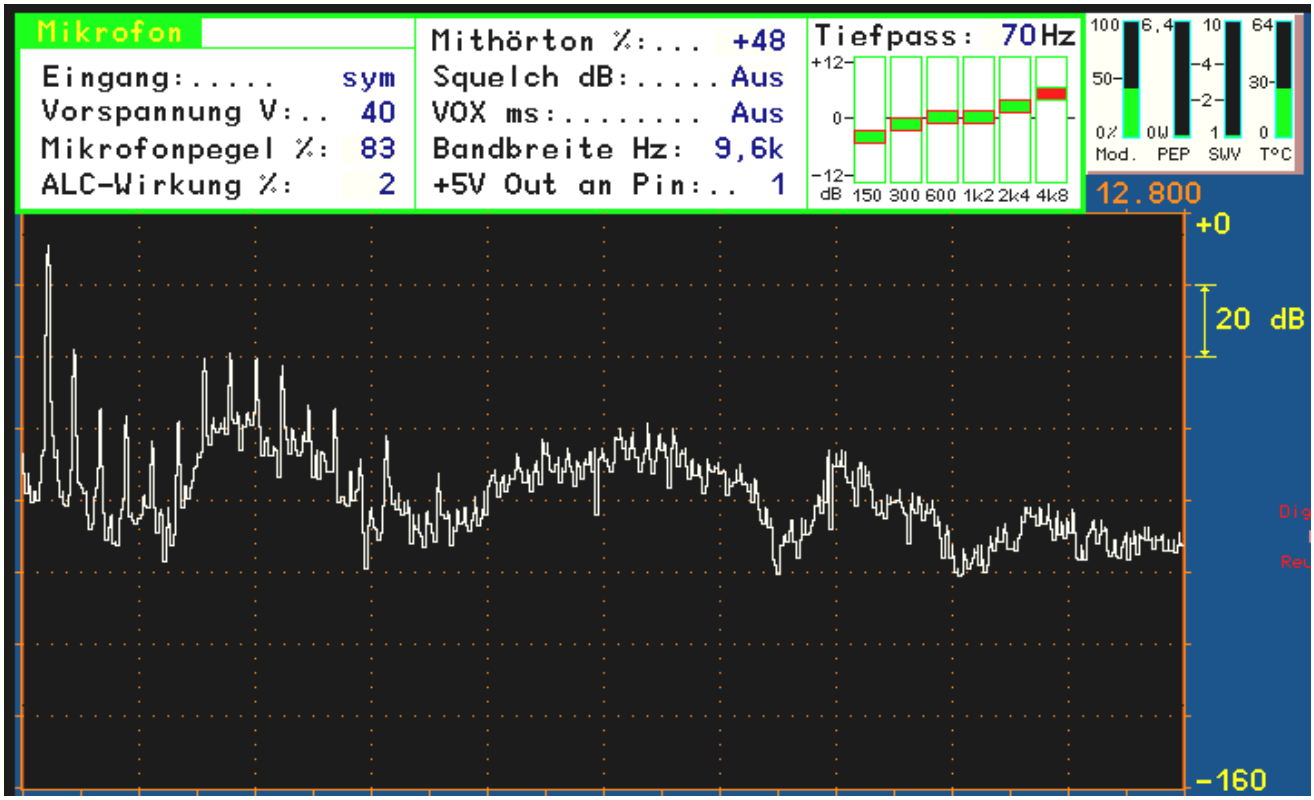
- "RX-delay ms:" Immediately after switching on the transmitter, the receiver is set to minimum gain (equivalent to "Manual" with -19.5 dB). After switching off the transmitter, it is hold in an insensitive state for the time of the "RX-delay" in order to suppress transients. After that time it is immediately put back on the defined maximum sensitivity (setting "control limit"). Should the received signal now be stronger, the AGC is adjusted immediately.

Attention! The value "0 ms" has a special meaning in connection with the monitoring (see dialogue "microphone"). In this setting, there is no switching of the AGC to the lowest gain value. The transmitted signal is received equal to all received signals and no extra monitoring tone will be heard.

Note: The "RX-delay" is the relevant parameter for the time needed from switching off the transmitter up to full sensitivity of the receiver. This time may be minimal if the TX signal is outside the reception bandwidth. However in case it is within (extreme: TX-shift = 0), it will be received depending from the RX / TX and RX switch settings. It will therefore trigger the gain control (upward or downward). The gain control would increase gain after the delay-time and only with the defined gain control speed. However, it is time for the "RX-delay" once again been fully regulated. It will be increased after the RX-delay time automatically to the full value.

Note: The parameter "RX-delay" is in the CW operation of particular importance, especially on CW VOX (VOX = 10 ms). With each trigger of the transmitter, the following sequence is started: TX-ON signal (PTT / button / VOX) à process time switched output à Start rising edge RF à End Edge RF à Signal à Start falling edge RF à End fall Edge RF à Signal TX-OFF (Switching output / RX trigger delay) à RX-delay à Set Gain RX. By choosing an appropriate RX-delay the operator can either opt for the fastest possible activation of the RX (and accept some switching noise) or chose minimal noise at the cost of minimal delays.

- "SSB-Shift": This value determines the position of the transmitted signal relative to the (suppressed) carrier in the SSB mode. The effect is exactly the same as the effect of setting "shift" at reception. In all other modes, SSB-Shift has no effect.



Configuration of the microphone settings: A spoken "iiiii"

F5 with frequency tuning not activated opens the microphone dialog. The parameters have the following meanings:

- "Input:" The microphone input can be connected unbalanced (one "hot" connection and a ground connection) or symmetrically (two "hot" terminals). See Wiring the microphone jack on the bottom.

- "Bias voltage V:" For active microphones a phantom power of 5 V or 40 V can be chosen. The bias voltage is only on one connection in the asymmetrical case, otherwise on both.

- "Microphone Level %:" Volume level of the microphone.

- "ALC effect %:" The microphone amplifier is equipped with an automatic level control (ALC).
-
- It reduces the gain at high levels to avoid clipping. The speed of the controller can be changed here.

- "Sidetone %:" When sending, the receiver is set to minimum sensitivity, so that the transmitted signal is not heard normally. When set otherwise (not “0”), a sidetone of the modulation of the transmitter signal is audible. In CW, a sound is generated, which corresponds to the setting "CW-tone" in the user interface. Negative values of the sidetone settings, create a phase shift of 180 ° in order to dampen any feedback which can occur.

  Note: If no RX-delay is set (see above dialogue "channel"), there is no reduction in receiver sensitivity. Thus even the received broadcast signal is audible (if in range) and there is no side tone generated!

  Note: In mode "SBCW" (combined SSB / CW) mode, when pressing the PTT key the SSB sidetone (microphone signal) will be generated; when keying with the Morse key the appropriate sideband tone ("L Freq" according to Memory dialog). Even if a double tone signal is sent into the sideband ("Freq L" and “Freq R" not equal to 0), only" Freq L " will be generated as a sidetone. In case "Freq L '= 0, then no sidetone will be generated, but a short-pulse (DC-impulse).

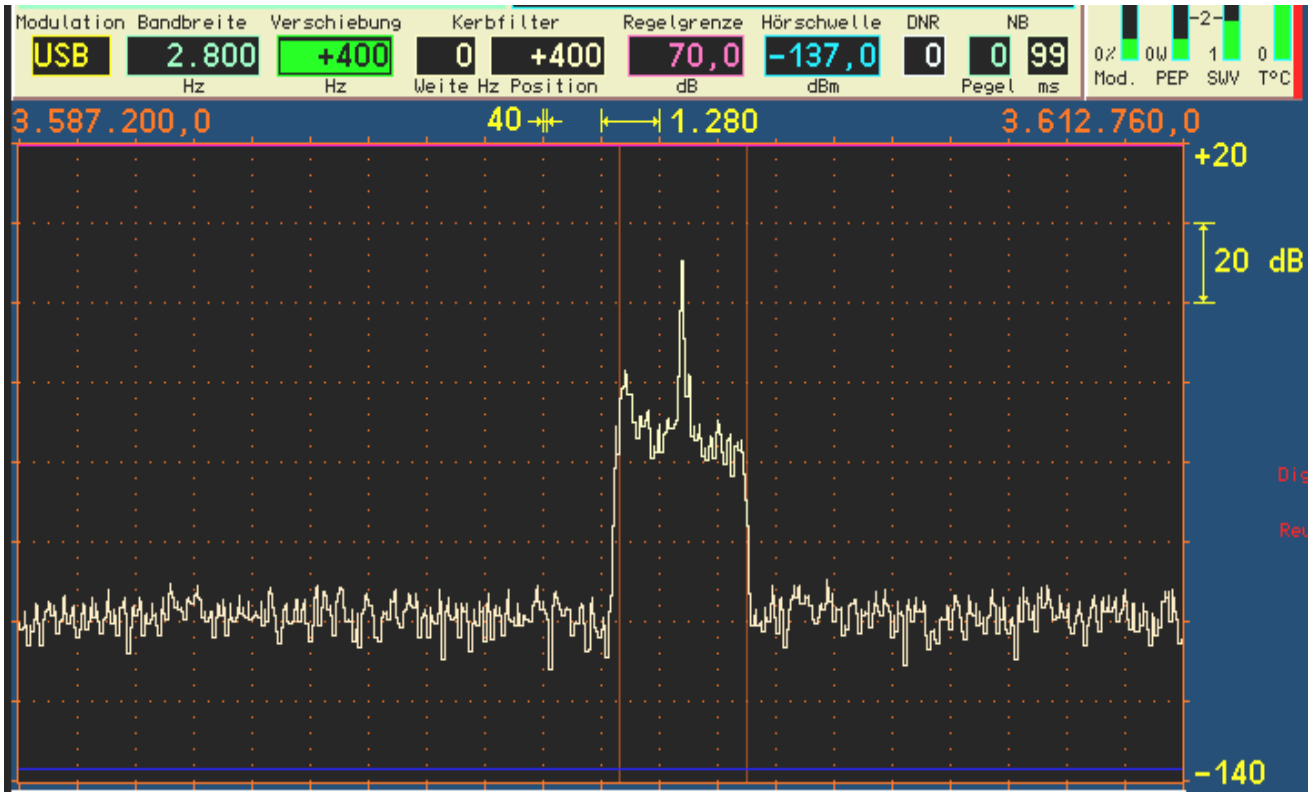
- "Squelch dB:" Below the squelch level the microphone will be switched off. Only levels above this threshold generate modulation signals. With activated VoX, this setting works as "anti-VOX".

- "VOX ms" hold time of the VOX (voice operated transmitter switching). With VOX activated (value > "Off") the transmitter is gated as soon as the degree of modulation exceeds 10%. The transmitter is switched off if the modulation degree did not exceed 10% for at least the set time.

- "Bandwidth Hz:" bandwidth of the transmitted signal. In FM it represents the cutoff frequency for the modulating signal. Up to 8 levels can be selected depending on the mode of 1.8 kHz to 9.6 kHz.

  Attention! The transmission bandwidth extends for AM and DSB of both sidebands. The highest modulation frequency which will be transmitted is only **half the size** as the set bandwidth range. In case of SSB the transmit bandwidth corresponds to the transmitted **AF-bandwidth**. For CW, the bandwidth setting has **no effect**. In FM the transmission bandwidth corresponds to a value from the set **Bandwidth** and the set **Deviation** (See The "Memory") following the theory of frequency modulation (Bessel functions).

  Attention! In the SSB modes (LSB, USB or SBCW) the location of the bandwidth in the AF-spectrum is defined by the setting SSB-Shift" in the transmitter dialogue.
  The lowest transmitted frequency results therefore from the value of the SSB-Shift, the top AF frequency of SSB-Shift + bandwidth. This corresponds exactly to the conditions when receiving an SSB signal. (The reception range can be fine-tuned by the chosen setting for "bandwidth", for the transmission case with the values of the dialogue "Microphone".)



Example SSB transmit bandwidth 2.7 kHz at 400 Hz SSB-Shift (here for a better view PBT is chosen at exactly the same size). This leads to a transmitted frequency range from 0.4 - 3.1 kHz beyond (USB) the totally suppressed carrier.

- "+5 V Out on pin #:" At the RJ-45 jack of your FDA20 module a power supply (max. 100 mA) can be switched to pin 1 or 2.

- "Low pass": Some steps from 100 to 800 Hz create a low pass filter in front of the ADC in the microphone channel.

- "Slider" for frequency control: In the microphone circuit a multi-channel tone control network ("EQualizer") is installed. With the sliders of the appropriate frequency range the level can be raised or lowered. The bandwidth of each range is designed so that adjacent frequencies can be influenced with a maximum of 3 dB.

  Extreme example: all settings at maximum. Then, for any frequency other than the lowest and the highest, an increase of +18 dB is possible (+12 dB boost on their own, plus each of the adjacent frequencies +3 dB). The lowest and the highest channel will have +15 dB boost.

  Attention! The equalizer comes behind the ALC in terms of signal flow! An amplification (increase) of the modulation signal can therefore not be compensated by the ALC and can cause overloading of the modulator with a hard limitation (distortion) of the signal. In this case unwanted spurious emissions rise over the allowed values of the transmitter! Use the settings of the equalizer in the positive range (increase) very carefully!

  Note: The Presets are tapped on the side tone or can be seen in the spectrum if the “microphone” dialog is open. The sidetone does **not** represent **the bandwidth limitation** according to dialog “microphone” ! The exact transmission signal can be made audible only by its own reception, use the setting "RX-delay" to 0 in the channel dialog.

11.4 Using the test generator

In the Memory dialog (F4), a test generator for the transmitter can be activated. The test generator is installed in the modulator of the transmitter. It is activated when a frequency setting of a test signal larger than 0 is present (as opposed to stereo test generator of the RX, which can only be activated via the calibration value "999").

The test generator is especially useful to test and calibrate the transmitter. The generated signals have a very high quality (distortion level well below 0.01% THD, SNR> 100 dB) and do not intermodulate with another. In the SSB modes with the two-tone modulation the intermodulation of the transmitter can be measured and calibrated via the dialogue "Transmitter".

- "AF-Level %": Level of the test generator. It affects both frequencies equally. The full output of the modulator is achieved with 100% level, regardless of whether both or only one test signals are activated.

  Note: The various filters in the transmitter have a certain amount of ripple in the passband (0.3 dB). At 100% level, it may come to clipping at certain frequencies. Then reduce the level set by a few steps.

- "FM deviation kHz": In case FM modulation is selected (setting "demodulator" in the user interface), the deviation can be set here. The value is for a modulation level of 100%. Depending of the demodulator (FM narrow or wide) both modulation types are stored separately and always used for the modulation of the transmitter. Common positions are 2.5 kHz for FM-N and 75 kHz for FM-W.

- "Freq L" and "Freq R": Independent frequency settings of the test generator. If set to "0" for both frequencies, the test generator is turned off. The frequencies are added in the modulator of the transmitter. If both are active, each signal will be used with only 50% level to avoid clipping. The frequencies can be set in 10 Hz increments up to 1 kHz and above (up to max. 15 kHz) in 100 Hz steps.

Note: The designations "L" and "R" have no meaning for the sender RPA5.

Note: The test generator is not affected by filter settings for the microphone channel. In the FM modes the chosen bandwidth serves as upper limit.

Mode "SBCW"

Besides being able to generate a test signal with the tuning operation (F2, "Tune"), the test generator has an additional task:

- Generate a sideband signal by pressing the morse key.

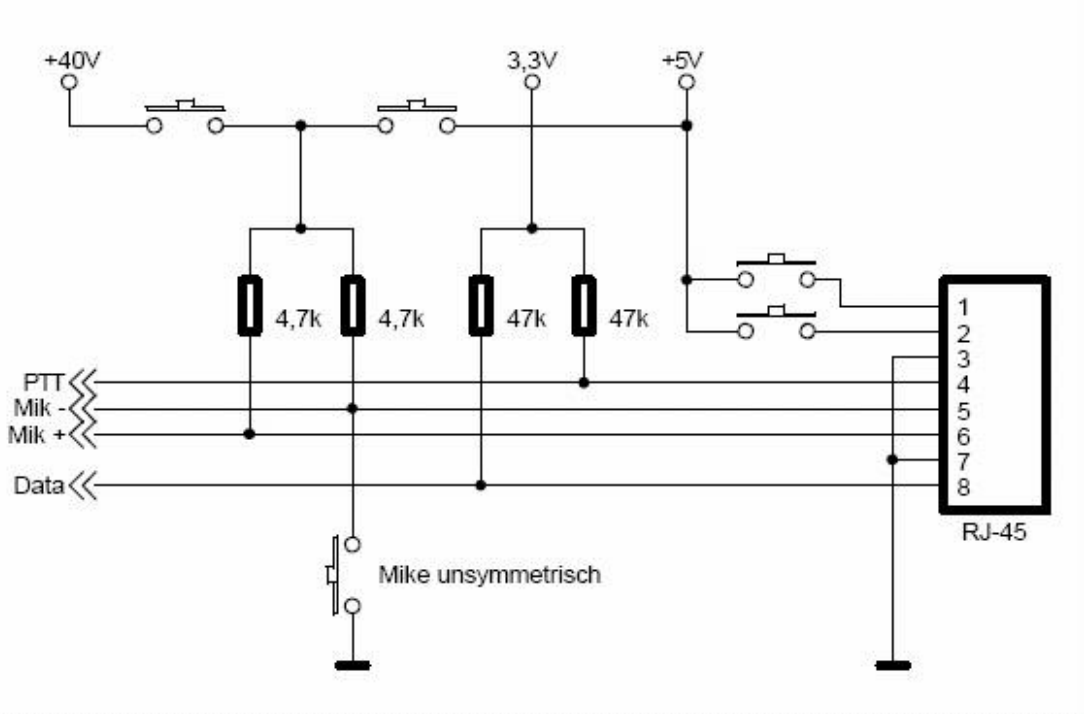
By pressing the PTT in mode “SBCW” normal SSB operation is established (automatic switching of the sidebands at / above 10 MHz). When pressing the Morse key, a tone frequency is generated within the sideband, whose frequency corresponds to the frequency setting of the test generator. With the level setting of the test generator, the volume can be influenced. It is also possible to activate both frequencies and to generate a two-tone signal within the SSB sideband.

Attention! The generated signal is not subject to the bandwidth limit of the transmission bandwidth (setting "bandwidth" in the microphone dialog)! Don’t select a frequency setting that is outside of your desired SSB transmit bandwidth!

Attention! If at least one frequency setting of the test generator is larger than 0, the signal generator output signal will be created instead of the carrier frequency in the tuning operation (F2, “Tune”). **In AM mode the AM carrier will be immediately turned on to full level and will use the generator’s signal only as a modulation signal!**

11.5 Connection of microphone, PTT and CW key to the transmitter module

The FDA20 module has an 8-pin RJ-45 jack for connecting a microphone with PTT button and a Morse key (or data input for digital modulation types). The pin assignment corresponds to the usual number of microphones from the amateur radio equipment (such as Yaesu, Icom or Kenwood) and is highly configurable (the switches in the circuit diagram shown below are software switches “on” and “off”). Existing or "favourite microphones" are therefore often directly connected.



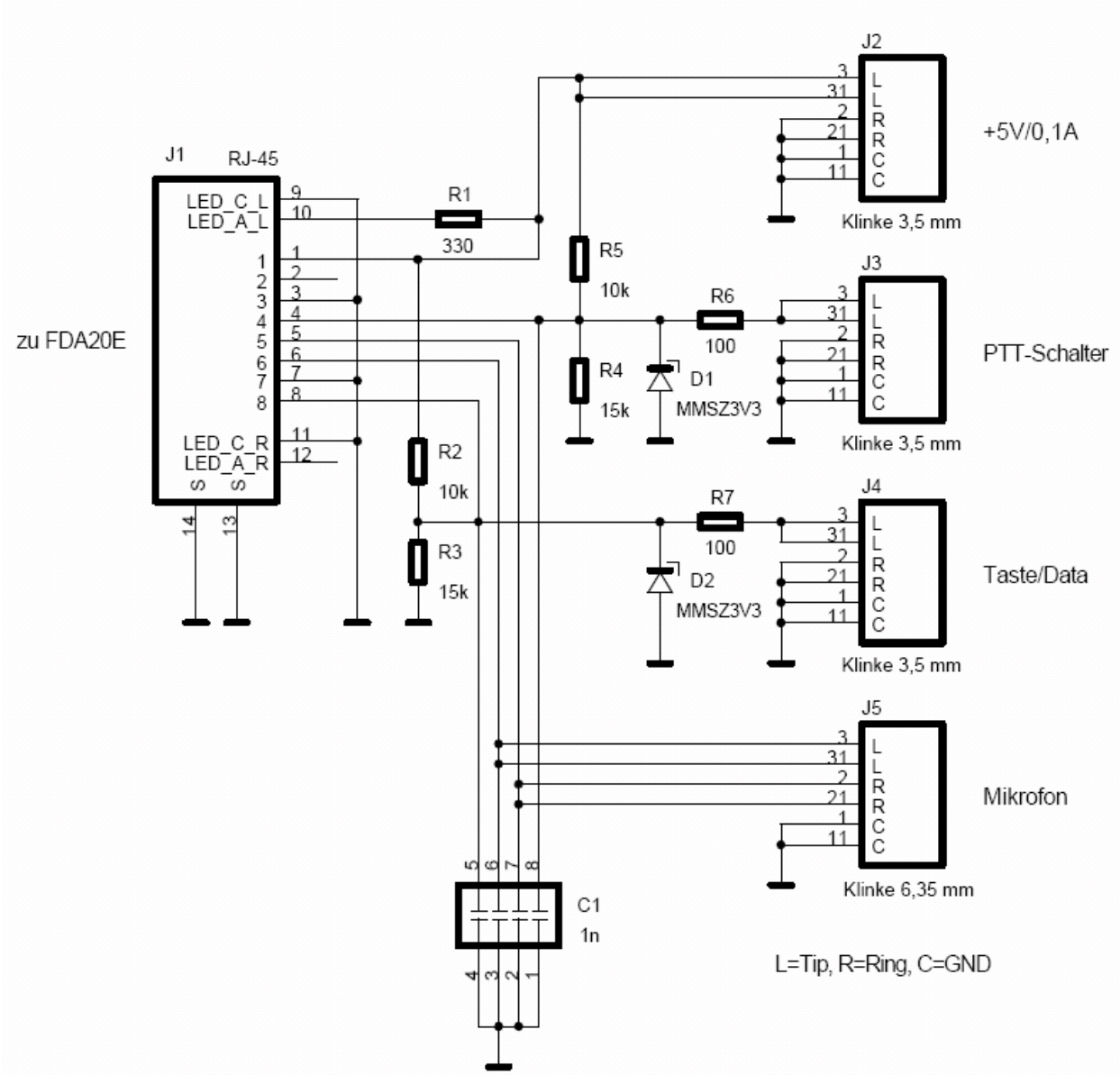
Internal circuit of the microphone jack on the module FDA20E

Optionally, a microphone-junction box with the connection contacts for PTT, data (key) and auxiliary supply +5 V (all 3.5 mm jack), and microphone cables (6.35 mm jack) can be provided for the RPA5C. For the switches any design can be used which switch the signal **to ground** (activation of the transmitter). Balanced microphones with XLR connectors can be used to connect to the microphone box using standard adapter cable from XLR to 6.3 mm. The picture below shows the internal circuitry of the adapter box.

Attention! In case you don’t want to use the adapter, the same circuit for connecting your own microphone / buttons need to be built. **In this case, the two voltage dividers for the connections PTT and data (key) are absolutely necessary! These inputs cannot tolerate more than 3.3 V voltage!**

Due to their high impedance open inputs can switch on the transmitter in case of noise pulses or suffer accidental damage from RF interference. **If the transmitter module RPA5C is installed, the RDR54 should never be taken in operation without connecting the module FDA20E to the microphone jack.** At all times, the connection box, an equivalent circuit or a microphone with matching inner circuitry has to be connected.

Adapter MAB5A



Internal circuitry of the adapter MAB5A

Pin assignment of Ctrl-socket

At the Ctrl-socket, switching signals to control an external power amplifier can be found. The signals have the following meanings:

- Pin 1 ... 4: BCD code (pin 1 = bit 0, Pin 4 = bit 3) of the currently selected band. 0 = no band (no TX possible), 1 = 160 m, 2 = 80 m ... 9 = 10 m band.

- Pin 5: TX-ON signal: active at once with PTT / button, inactive after the falling edge of the RF signal.

All signals are +5 V positive logic (1 = enabled, 0 = inactive) with 150 ohm impedance (TTL / +5 V CMOS-compatible). The "Ctrl" Jack is a 5-pin mini-USB connector.

The female "+13.8 V / 1.0 A" is used to power the transmitter. The connection must be made through a 2.1 mm hollow pin connector, the positive pole is located on the inner pin.

Jack "ANT5" is the RF output socket of the transmitter. Here, the antenna or an external power amplifier needs to be connected.

Attention! Never operate the transmitter without terminating it with a real 50 ohm load!

Jack "Ant1" is connected via a transmission / reception switch to ANT5. You can connected it directly to the Ant1 jack of the ADC module (input shortwave receiver) if an antenna is connected to ANT5 **or** the external power amplifier sends the signal back to ANT5 when receiving. Otherwise, the antenna signal needs to be sent back to the receiver input via an external antenna switch.

Attention! Do not exceed the maximum input level of the receiver input under any circumstances!

11.6 Additional Information

The transmitter has a different means of protection. In case one of them gets activated, the transmitter panel in the user interface turns to color “red”. The error condition may be reset after checking the cause! Either by pressing the F2 key "tune" or change various settings (eg change of modulation or call for a dialogue).

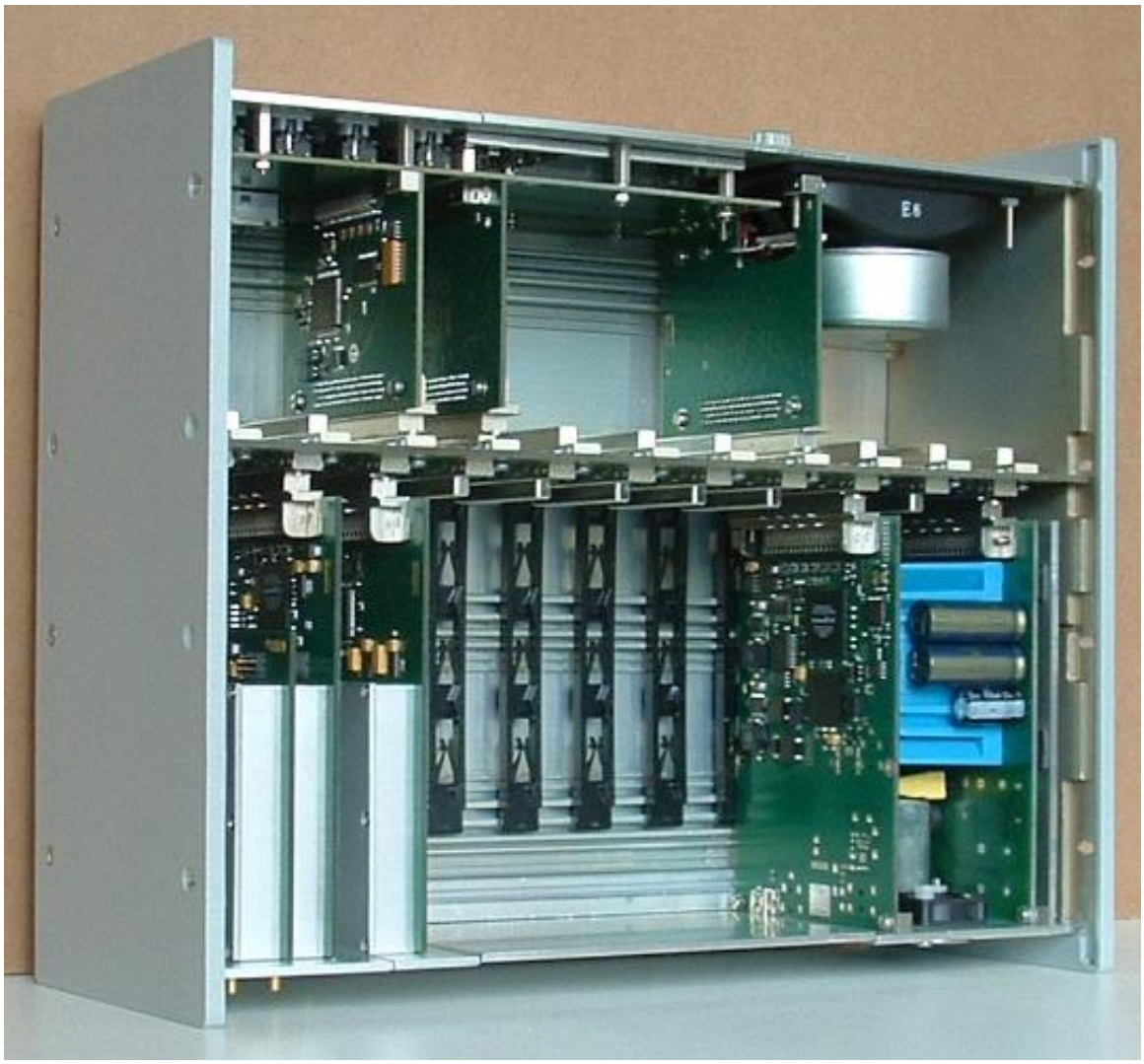
With the internal power supply (no DC power supply connected to the "+13.8 V" jack), a maximum output power of +34 dBm can be achieved. For CW or FM the internal power supply is then fully loaded and comes with a limited tolerance of the supply voltage of +-5% at 230 V~. If the RDR54 is operated only briefly at a lower voltage, or in case of short term peaks while operating the buttons, it can happen that the device turns itself off completely without warning. The transmitter should be operated with a smaller output power than +34 dBm without an external power supply.

The above performance data are based on a real load resistance of 50 ohms. A special feature of RPA5C transmitter is the automatic adjusting of the internal resistance to the load resistance within certain limits while maintaining the output voltage. This increases the power output down to the lower load impedance, at higher impedances it drops accordingly.

For small load resistors or in case of a short-circuit the output stage can be overloaded. In case of a standing wave conditions exceeding 10, a measured output larger than 7 watts or at an internal temperature above 70 ° C the unit will shut down.

In the 20m and the 15 m band, a SWV of 10 or higher cannot be achieved in case the impedance is somewhat higher. Nevertheless, this condition needs to be avoided, since the output voltage can only be maintained approximately and harmfully high values can be achieved when idling!

12.) Installation instructions for modules



Expansion modules such as RFM32 or RPA5 can be mounted on the back of the RDR54 (pictured below). You need the following tools and components:

- Spline Screwdriver (Torx) size T-9 and T-10.
- Expansion Module.
- New blank front panel.
- Optional SMB cable of appropriate length.

In order to install a new module proceed as follows:

- **Remove the power cord!**
- Remove the 4 screws on the right and left sides at the top of the housing. Caution, the screws are greased, place it on a dry, lint-free storage for later reuse.
- Loosen (front view) the screws on the right side at the bottom of the housing by about 1-2 mm.
- Press the right side of the case carefully at its top to the outside (about 4 - 5 mm).

The top lid is now released and can be raised at the right side.
Pull the cover from the left side towards the right and lift it off completely. Advantageously, memorizing the sides (or mark it) in order to make the reinstallation in the same position.

- Loosen the screws at the bottom of all the modules up to the desired slot by about 1 mm.
- Remove the blank faceplate from the slot by unscrewing the bottom screw (s).
- Plug in the module into the desired slot (preferably right next to the existing modules). Slide it to the back of

the PCB bottom edge of the guide rail until the connectors of the module touches the backplane connector. Now plug it in alongside the connector with a slight variation of the vertical orientation and height of the module.

Attention! The module may not jump out of the guide rail (don't lift too far). Try the operation again from the rear edge of the casing.

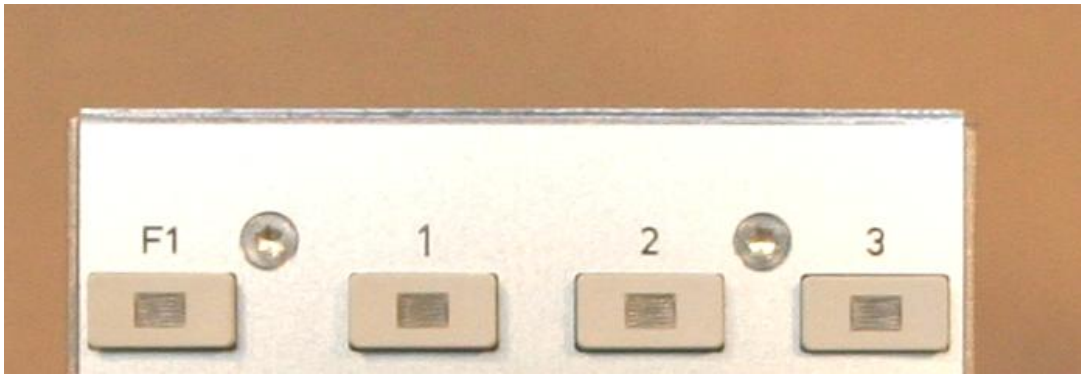
Attention! During the last 2 mm of the insertion distance, the EMC seal is on the side of the module front plate in contact with the front plate of the adjacent module or vice versa. Be careful not to damage the seals.

In this insertion state, the lower edge of the front plate comes into contact with the housing bottom. The last 2 mm can only be fully inserted when the bottom edge is aligned horizontally and are accurately positioned towards the edge on the bottom.

- After inserting the module, a new blank front panel can be inserted (if required). Pay attention again to the EMC seals. The loosened modules can be shifted (seen to the left from the back) to the side in order to be able to insert the blank front panel. If needed, the fastening screws can be removed completely, the modules on the other side (eg the module RDR25) can be loosened and shifted to one side. In case there is still not enough room, you can loosen the side(s) (continue to unscrew further).
- Don't fasten the screws hard! In particular, the bolts of the blank panel may only be lightly tightened so that the plate is not pressed on the top of the housing.
- Put the lid on the housing. Start with the left side (seen from the front) by sliding it into the recess of the left housing wall while holding the lid in an angled position. Press the lid down gently (decrease angle to horizontal) until it rests flat on all front panels.

Attention! The upper edges of the face plates press against the guide rail on the inside of the lid. In case the edge of a module has been moved far to the inside, so that the lid does not slide over the edge of the front panel not even by firmly pressing or tapping on the lid, loosen the screw of that module a little and press the top slightly outward.

The tapered top edges of the front panels need to fit into the recess of the cover (tongue and groove principle). You may tap lightly with the hand on the lid until it is correctly positioned on all front panels.



The milled top of all the modules must engage fully into the groove of the lid.

- Insert any necessary connection cables to the sockets.
- If loosened during installation, retighten the screw of the power supply module RPS25 !
- Plug in the power cord, turn on the device and install the software if necessary by connecting a PC to the USB port of RDR25 module.
- Check the correct function of the module and the entire device.

Should no function be observed or the device not start (user interface screen does not appear) check the required software components in the boot loader (note the instructions for each version). Should the device not power up at all or the correct software be installed and still no function be seen, remove the lid again and check the correct position of all modules (fully plugged in, front panels lie horizontally on the edge of the housing base, screws are tightened slightly. ..).

Attention! Remove the power cord before working inside the unit!

If not everything is OK, remove the blank faceplate and the newly installed module out of the device. Inspect the

pins of the connector on the module, make sure that no pin is bent (at the bottom of the module seven pins are missing intentionally). Should one or more pins be bent, you can try with tweezers or a similar tool to gently bend it back straight. Otherwise, return the module for repair.

- If everything works as it should, press the right side wall back to the device (lid must be inserted into the slot in the side wall), screw the lid back on and tighten all the removed screws in the modules and the side walls securely. Do not apply excessive force to avoid damaging the threads.

- Should a type label be attached to the front panel, we ask you to remove it gently and glue it back onto the new blank panel. Use a commercially available adhesive, such as super glue.

13.) Current extensions

The RDR54C is constantly evolving. This applies to the software of the device, as well as individual components. New software can always be installed on the boot loader and make several improvements and enhancements of the functionality possible. New modules can be installed in addition or in exchange for older modules into the receiver.

13.1 Software V3xx

This update contains some minor improvements and bug fixes over the version 300. In addition, the following new features were added:

- Menu "Audio High-pass" in the Setup dialog. With this setting of 20 Hz - 300 Hz, an attenuation of low frequencies can be achieved in the audio module FDA20. In particular the speaker of the module FDA20E allows to play at very low frequencies, resulting in a rather dull sound at larger volumes or high limit of higher frequencies (narrow filter setting). With the attenuation of the lower audio frequency range a more balanced frequency response is achieved.

- "Quick change" from any set-up position to the frequency display (except for built-in transmitter RPA5C). After pressing the F1 key to activate the grid stepping, you will jump immediately to the frequency setting and not return to the previously active set. This way you can quickly jump to frequency adjustment by pressing twice “F1” without the using adjustment knob (using “push and rotate”).

- New demodulator "EUSB". This is an extension of the USB demodulator (Extended Upper Side Band). An imaginary carrier frequency is assumed at the left side of the spectrum and not in the middle. Then the entire spectrum width is available to the right (with appropriate adjustment of the frequency resolution) and not only the right half. The maximum bandwidth limit + offset is set to 15 kHz audio frequency.

The importance of this demodulator is particularly given at very low frequencies (ELF) such as lightning observations, "Whistler" reception, submarine or radio observations of the Earth's magnetosphere. It is possible to receive from 0 Hz on in case the display middle frequency is set to the minimum value; just press any number key other than "0" key and click "OK" button (or “F5”).

This mode produces a reproduction of the received EM waves with exactly the same audio frequency without any conversion or shift. As soon as the receive frequency is increased (the left edge spectrum larger than 0 Hz), a corresponding frequency conversion will happen so that the reception frequency at the left edge of the spectrum resembles an audio frequency of 0 Hz.

The inputs of the RDR54C are not DC coupled, 0 Hz (DC voltage) is thus not measurable. Instead, at 0 Hz the DC offset of the ADC is visible. If this interferes with the AGC (in this range it hardly makes sense), a suppression can be achieved by setting the shift of some 10 Hz. Similarly, the shift helps in suppressing strong low-frequency disturbances such as hum. The notch filter is also fully functional at EUSB.

Ant1 input allows reception from about 1 kHz on (-3 dB). At the input IN1 (not provided suited for antennas, only for extensions!) a reception from about 300 Hz on is possible. At least one external protection circuit needs to be provided! Advantageous is the use of preamplifiers / impedance converters (FET preamp) to this input. A level calibration of the displays can be performed by the appropriate setting in the Memory dialog.

Ant1 circuit with the input impedance of 0 ohms results often in a good reception when connected to wire antennas or a loop antenna.

Attention! Do not forget to switch to 1 kHz as the lower frequency limit in the Setup dialog in case you want to use ANT1 input!

V302:

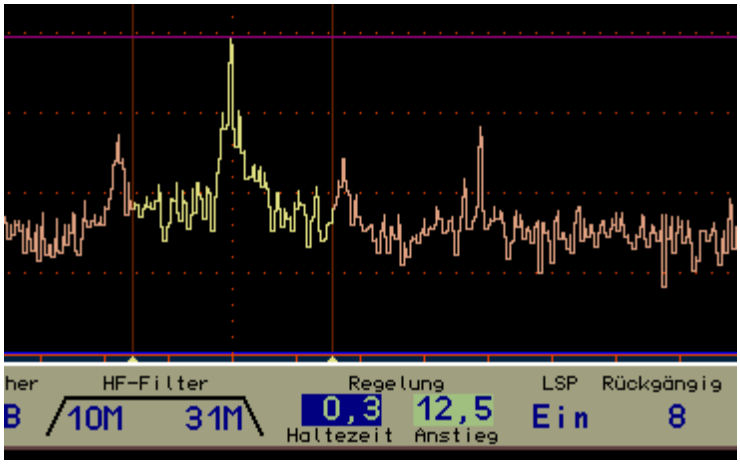
- Fast sideband demodulator choice in "Auto" by pressing the "0": LSB, USB, DSB ("Carousel").

- Direct frequency input in kHz ("F4") or MHz ("F5") values, each one decimal place is possible.

- Various minor improvements in control and filtering algorithms.

V303 (German) and 404 (English):

- Quick access to the AGC control parameters in the lower panel of the user interface. No longer the setup dialog has to be opend. Now the settings are directly knob "approachable".



The vacated entries in the Setup dialogue are now assigned as follows:

- De-emphasis switch for FM wideband demodulator: Off, 50 microseconds , 75 microseconds.
- Audio low pass filter to reduce audible high frequency noise: 0.5 ... 15 kHz.
- Audio high pass filter to attenuate low frequency noise (hum, etc.): 20 ... 300 Hz.

- Inside the Memory dialog, the delay time of the Mute-switch module RAS12 (see below) can be set ("RX Delay") . This value specifies the amount of time after shutdown of PTT the receiver switches to full sensitivity again. The RDR54 has about 180 ms signal delay time. If this or a larger time is set, no residues of the own transmit signal will be audible.

- The S-meter will now scale correctly with frequencies above 30 MHz. There, the S-points are 20 dB lower as is the case in the range up to 30 MHz.

- When turning on the FM-W demodulator stereo decoder the S-value is hidden. The level indicator reports in this case the modulation of the MPX signal (0 dB = full scale at 75 kHz deviation), and not the RF input level.

- Quick mute the audio when the demodulators are switched to avoid loud switching noise.

The user interface is available from this version in English. The name always contains a "4" in the first place, eg V404 as an English version of the V304. In the German version, some settings have been renamed in order to maintain compatibility. For example, the demodulator “Auto” is now called SYNC and the FM demodulators FM-N (narrow) and FM -W (wide).

Vx06/7:

- S-meter range extended downwards. If the video display is set to less than -140 dBm for the bottom margin, the S-meter measures up to the lower limit of visibility, minimally measure up to -160 dBm. Even the demodulators can now work as deep as -160 dBm, AM and FM at the noise limit of the RAD18 ADC (see below) above 87,5 MHz (-150 dBm) are demodulated. The demodulation threshold (squelch) can be turned off by set it to the very lowest level (readout "Off").

- More selective filters for AM-H and FM-N. The filter characteristics of the non spectrum-based demodulators AM-H and FM-N were greatly improved. The width is now slightly less than stated in the setting, the slopes are significantly steeper. At 10 KHz bandwidth AM-H (real now about 9 kHz) can suppress adjacent carriers (5 kHz tones) with about 90 dB.

- Modified AGC for spectrum-based demodulators. The AGC can keep signals over a dynamic range of 140 dB ± 1 dB constant. This way the noise was also highly gained when the control limit was set accordingly low. Now the AGC no longer moves the gain-control deep into the noise. A possible "popping" of the AGC with fast signal jumps out of the noise is greatly reduced too.

- Calibration also affects the transmitter. The frequency calibration in memory dialog now affects the TX frequency exactly equal to the RX frequency. One listens and transmitts always at exactly the same frequency (± TX-Shift), regardless of the general quality (accuracy) of the calibration.

- RDS decoder for FM radio reception (only for units without transmitter control). When a station is being received with sufficient strength of the RDS signal, the RDR54 decodes the signal and displays the program type and channel name on top of the MPX-spectrum (across the frequency readouts). A dialogue with further informations can be opened by pressing "0" if the active cursor is placed on the spectrum width setting (yellow indicator of the horizontal resolution on the chart between the RDS texts). To mark the special function of the "0" button its LED lights in this case.

The RDS dialogue can be seen in the description of the software enhancements RDR50 (on page 93).

In FM radio stereo mode, the setting "Width" (usually used for the width of the notch filter) now has a different meaning. It then serves to adjust the stereo width. Thus, the with can be set from mono (0 %) to stereo (100 %) and even beyond to double width (200 %) in steps of 1 %.

The software is available in the following variants:

V306 : German with non-RDS demodulation but TX-control.
V307 : German without transmitter but with RDS.
V406 : English with non-RDS station but TX.
V407 : English without TX / with RDS.

Vx010/11:

- Control of the new modules RAD18DF and RDA31B/C (see below).

- Changed filter bandwidths for AM-H , FM-N and FM-W or customized ads for changes already made in the previous versions of the modified filters.

- Video averaging filter can now be switched to averaging over several spectra (1 = no averaging ... 128 = averaging over 128 spectra). Additional minimum-hold filter to suppress unstable signals (eg noise) and highlighting stable signals (eg measured signals).

- VOX threshold and anti-VOX, bridging of high-pass filter and equalizer. See page 95: description of the new microphone dialogue.

The software is available in the following variants :

V310 : German with non-RDS but TX-control.
V311 : German without transmitter / with RDS.
V410 : English with non-RDS / with TX .
V411 : English without transmitter / with RDS.
V412 : English without transmitter / with RDS (American decoder).

V114 : Old software "measuring receiver " (see separate operating instructions).

13.2 Replacement / Expansion Modules

RAD17D(F) ADC module

The ADC module RAD17 in the D version has a special pre-amplifier in discrete circuitry. A small power MOSFET in complementary push-pull circuit ("CMOS") are used in the lower frequency range up to 1.8 MHz. Above a GaAs-HEMT amplifier is used. In both cases the signal path is totally balanced, reducing noise and distortion.

In RAD17D (almost) no switchable filters are available, but the pre-selection for the two built-in ADC is realized by a real preselector. It consists of a double circuit, tunable band-pass filter. Specifically from 3 pieces of it :

- 0.5 to 1.8 MHz
- 1.8 to 8 MHz
- 8 to 18 MHz

The band filters are tuned electronically and fully automatically (following for frequency setting). Yet they do not impair the freedom of the high distortion free preamp.

The preselector has a relatively large bandwidth and low slope. It always has to pass through the full RDR54 processing bandwidth of 164 kHz. This works on the low frequency end narrowly, there is a bandwidth of approximately 150 kHz. At the upper end it increases to more than 1 MHz. Below 500 kHz and above18 MHz receiving frequency fixed low- or high-pass filters are connected .

In the dialogue “Setup” the preselector can be set to manual operation. Then the displayed frequency of the filter (bottom panel of the user interface) might be selected (just like any other set on the surface) and can be varied by the encoder. The step size is a minimum of 10 kHz, otherwise the step size for the frequency setting.

The module RAD17D is mechanically exactly the same structure as version C and thus interchangeable. Both modules can not be run in parallel ! The broadband input IN1 of RAD17D 0.1 - 150 MHz has no more accuracy. Primarily it exists only for the connection to the FM module RFM32.

Into devices RDR54D the ADC module D version is installed by default.

A further development of the ADC module RAD17D is the version 17DF (see picture above). This module also contains preamplifier and filter for the 3 m FM broadcast band and for the 2 m amateur radio band (144 - 148/154 MHz). It can thus replace the separate module RFM32 for FM reception. From software version Vx06 / 7 the reception area of the RDR54D when using module RAD17DF is extended to 154 MHz without significant loss of sensitivity (usually only up to 148 MHz).

RAS12A

The module RAS12 Version A can be connected in front of an ADC module for separating the input signal. This way the suppression of strong signals from up to 70 Vrms is possible. Main area of application is disconnecting the antenna when connecting to transmitting amplifiers.

The disconnection is done via input "PTT" by opening the signal path using a fast and inaudible reed relay. This relay switches the input "INPUT" (antenna) via a crossover to the outputs "ANT1" and "ANT2" which can be directly connected to the corresponding inputs of the ADC module (normally reception). " INPUT" is then fed from the transmit / receive switch of the transmitter.

Upon activation of the PTT signal, the input is disconnected immediately. In addition, the device is set to drastic reduction of the receiver gain. After deactivation of the PTT signal the input is turned on again immediately, but the gain is switched on after an adjustable time. The receivers AGC is then precisely set back to the value before the shutdown (prevention of desensitization) .

The muting module includes protections to limit short-term surges:

- Coarse protection 90 V Gas Tube with 10 kA load and erase varistor.
- Fine protection Transzorb 5 V / 16 A diode load .

Furthermore, the module is equipped with a permanently powered preamplifier (version A, version B has no PreAmp). The preamplifier has about 14 dB of gain with a noise figure of about 3 dB and an input IP3 of +20 dBm.

Due to the very low noise figure, the noise level of the RDR54 drops almost to the value of the pre-amplification. Thus, especially with RDR54**C,** a significant improvement in sensitivity can be achieved (approximately at the level of the module RAD17/18D with switched on PreAmp) . The IM-suppression is higher than that of RDR54D with module RAD17D.

The preamplifier has a 1 dB input compression level of about 0 dBm. Since it is never switched off, the attenuator of the ADC module must be switched on from about -13 dBm input level to use this high signal levels.

RAS12 can be combined with the transmitter modules RPA5 (if not its internal but an external antenna switch is used) and RDA31C. In these cases, no external connection transmitter → PTT Out to RAS12 → PTT In is necessary. The transmitter module automatically actuates the switch via an internal connection.

RAD18DF

The ADC module RAD18 was originally developed as a pure FM ADC module to achieve high-end FM reception. The effort required also enables excellent properties in the range 0 - 54 MHz. Therefore, a version DF ("F" = always 3 m and 2 m band built-in) was created for this area. RAD18DF is characterized by the following properties:

- 4 pieces of the lowest noise available 16-bit ADC chips in double push-pull circuit.

- Built in low noise preamplifier with "boost" option and high IP3.

- 20 dB attenuator and preselector of RAD17D (see above) can be used. Devices with S/N above 051 has 31,5 dB attenuator switchable in 0,5 dB steps.

- Special low-noise clock output for synchronous control of other components (DAC).

The module provides the interconnection of the four 16-bit ADC chips to an 18-bit RF data stream having a bandwidth of 1 kHz ... 150/154 MHz. Up to 30 MHz continuous reception is possible (31 MHz low-pass filter + preselector of RAD17D), the 6 m band of 50 ... 54 MHz is filtered with an LC filter, 3 m FM radio and extended 2 m amateur radio band (up to 150 MHz without damping, to 154 MHz with increasing damping) are limited with multi-pole SAW filters. This module achieves very high sensitivity and intermodulation resistance.

The noise-line at a spectral resolution of 20 Hz (working range of the spectrum based demodulators / audio signal generator) is up to 54 MHz approximately -136 dBm (+6 dB preamp), in the VHF range at about -150 dBm.

RAD18DF can be installed in any existing RDR54 receiver / transceiver (older ADC modules must be removed).

RDA31B

RDA31B is a tool to monitor AF- voltages up to 40 kHz (sampling frequency of 81.92 kHz). In RDR54 there is the issue of the two stereo channels when the modulation "FM -W" is on. Even with AM-E, FM-N, BaIQ and BaIF.

The module contains a high-quality 24 bit sigma-delta converter ("Advanced Segment Architecture") with a signal to noise ratio of 127 dB and a total harmonic distortion of 0.0007 %. This far exceeds the possible signal quality of an FM transmission and can output the full quality of the FM demodulator in RDR54 without further interference.

The output signal is raised using equal quality amplifiers to a maximum of 3.5 Vrms (open circuit) on monitoring output "Phone". Here headphones with a resistance from 25 ohms can be connected directly.

The RCA jacks "L" and "R" indicate exactly half of the phone voltage with an internal resistance of 75 ohms. Here high-quality audio amplifiers can be connected.

The output level is adjustable from 0 - 100 % in 1 % increments. The setting "AF level" in the Memory dialogue (see page 36 "Memory dialog ") serves to do this adjustment.

Caution! The monitoring output and the RCA outputs work directly in parallel. The level setting affects all outputs simultaneously.

Inside the RDA31B module there is a low-frequency signal generator integrated for testing purposes. It is activated instead of the normal AF output when the frequency calibration in the memory dialogue is set to "0". In this case, the two test frequencies "L" and "R" will be generated at the corresponding outputs of the RDA31B. The signal generator is working digitally with 18 bit resolution and reaches about 100 dB THD+N.

Caution! The level adjustment also affects the test generator. At a level of about 70 % (depending on the load on the outputs) the full output voltage is supplied. At higher settings, the output voltage is limited (hard clipped) !

RDA31C

The DAC module RDA31C is a modulatable signal generator for use as an "Exciter" when operating the RDR54 as a transceiver with external power amplifier (PA). It was developed to output very high signal quality by using an advanced dual 16 bit DAC with a special clock generation. The RDA31C module can generate the following signals:

- One -or two- tone test signals in the range of 81.92 kHz - 154 MHz.

- Modulated signals (from microphone and test generator input) in AM, DSB, SSB, CW, FM Narrow and FM Wide.

- PTT signal with adjustable delay (transmit-receive switching).

The output power is 5 mW (+7 dBm). Above 54 MHz, the output power is reduced by approximately 2 dBm. The high signal quality also allows the control of transverters for operation above 154 MHz.

The exciter module RDA31C should be used in conjunction with an ADC module, which provides a high quality clock source (eg RAD18DF, see above). In case of non availability of such a high quality clock source (eg RAD17C/D ADC) the signal quality is degraded.

Controlling the module is possible with software from version 310. Here, the RDR54D behaves just as if the transmitter RPA5C (see section 11 on page 57) would be installed. The RDR54 becomes a HF / VHF transceiver (with external PA). The RAS12 module can be used for transmit-receive switching, if no highly insulating antenna switch in the PA is available.

Facing similar operation with RPA5 by use of the RAD31 arises the following differences:

- The transmit function can be set to any frequency of the RX. There is no limit on amateur radio bands or certain types of modulation (observe permissible transmissions !).

- The output level is in the range -6 dBm to +7 dBm adjustable (TX dialogue).

- Special adjustment settings (SFDR or IM) are not required / available (TX dialogue).

- There is no internal antenna switch to loop the received signal to the RX (ADC) input.

- There is no output with information of frequency setting / band selection etc. available.

- The display panel for the transmitter output level, SWV and module temperature are not active.

14.) RDR50A

The RDR50A is based on the RDR54C and contains all the essential hardware and software components. The device is not manufactured as a modular design, instead, the entire circuit is located on a large motherboard. The RDR50A contains neither a 230 VAC power supply nor a keyboard. The operation is done via a (larger) touchscreen display.

RDR50A1

14.1 Differences to the RDR54C

The specifications are similar to those of the RDR54C with the following exceptions:

Frequency deviation (internal oscillator):	<± 3 ppm min after 10 min., internal manual calibration
external synchronization:	not available
max. processable input level:	+6 dBm, no attenuator available
Preamplifier (switchable):	not available
Level of inaccuracy:	<± 3 dB
Bandpass filter (-3 dB limit):	1 kHz - 520 kHz, 520 kHz - 1.8 MHz, 1.8 MHz - 6 MHz; 6 MHz - 14 MHz, 14 MHz - 30 MHz, 50 MHz - 54 MHz; selectable or automatic
Resolution time-frequency conversion:	5 Hz ... 320 Hz in 8 steps (each doubling)
Speaker channel:	Spread-Spectrum PWM, 5 V level, Ri = 0.1 ohm, internal filter and 4 ohm speaker, diameter 75 mm
Headphone channels:	2 channel, independent stereo, DAC 18-bit, max. 13 mW into 16 ohms

Display (WVGA):	TFT 7.0" (177.8 mm) diagonal, 800 x 480 pixels, 256 colors, max brightness 320 cd / m², viewing angle (horizontal / vertical) 120 ° / 90 °, contrast (black / white) 400, response time 25 ms, touch panel operation
SMB connectors (male):	ANT1 (1 kHz ... 30 MHz), ANT2 (50 ... 54 MHz),
Other connections:	3.5 mm stereo headphone jack, 2,1 mm pin connector DC power supply, Mini-USB 2.0 Type B, high-speed 480 Mbit/s
Power supply:	12 ... 15 V DC, 2.5 A, <0.01 A standby
Size (width / height / depth):	290 mm / 155 mm (feet folded up) / 245 mm
Weight:	max. approximately 4.5 kg, depending on the version / equipment

There are 4 versions of RDR50. RDR50A1 version complies with the above specifications. RDR50A2 version also contains the FM section corresponding the description of the module RFM32B of the RDR54C. RDR50A3 version also contains the transmitter module according to the description of the RPA5C of the RDR54C. RDR50A4 version contains an additional FM circuit plus transmitter.

Depending on the version, additional ports are available (some even on devices with a lower version number, there but not enabled).

SMB connectors (male) Revision A2 / A4	ANT3 (87.5 MHz - 108 MHz), ANT4 (144 - 148 MHz)
SMB connectors (male) Revision A3 / A4	ANT5 (1.8 MHz - 29.7 MHz output), To RX (output antenna switch)
Other connectors version A3 / A4	PTT 3.5mm jack, 3.5 mm jack KEY; Mike 6.35mm jack balanced, Mike 8-pin RJ-45 connector, RJ-45 connector CTRL 8-pin

14.2 Operation

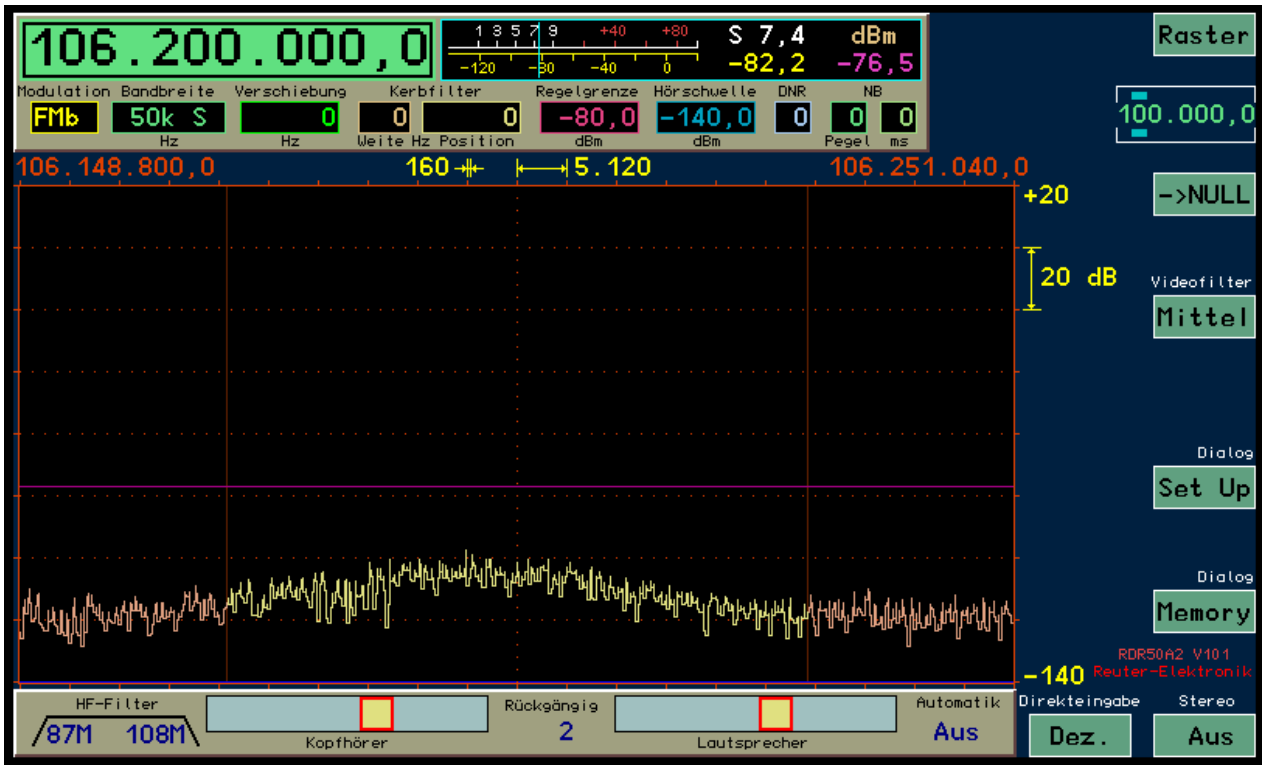
The operation of the RDR50A corresponds basically to the operation of the RDR54C. Depending on the device's version corresponding features are also available. The main difference is the lack of keyboard with the numeric keys and function keys, as well as the non-existing "push" function of the main tuning knob. Even the knob to adjust the volume as in RDR54C is no longer needed.

These control functions are realized by a touch-sensitive surface of the display called "touch screen" or "touch panel". In order to trigger a function, the icon / object in the display presentation must be touched. This can be done with the finger or with a blunt object, such as a plastic pen. With a little bit of care, the operation of clicking the touch screen with your finger nails works quite well. The trigger function takes a little bit time (debounce), we recommend to the press the desired control for at least 0.5 s. About the same time you must wait until tap to another location or trigger another operation.

Important! **Never touch the touchscreen with something hard, sharp or with pointy object such as metal, ceramic, glass or the like!**

This would result in a destruction of the surface and thus made the touch screen unusable and reading the display impossible. Such damages are not covered by the equipment warranty!

The user interface has been enhanced to carry out the touch features of some objects. This includes the following settings:



User interface of the RDR50A.

- "Slider" to adjust the headphone and speaker volume: tap the yellow "Push button" and drag it to the desired position. It can also be tapped directly at the desired position. At low levels, the setting is then immediately changed, at higher values, the position moves slowly out to it to avoid a sudden high volume.

- Frame around the screen step-setting: The desired adjustment position of the grid (blue bars) can be taken as the volume control to the left and right.

- "-> NULL ': The active “0” key on the RDR54C for setting frequency and grid setting to integer values and the rounding operation for all value entries.

- Button "Dec." Brings up touch-sensitive window in which decimal numbers of values can by typed in (not in all dialogues possible).

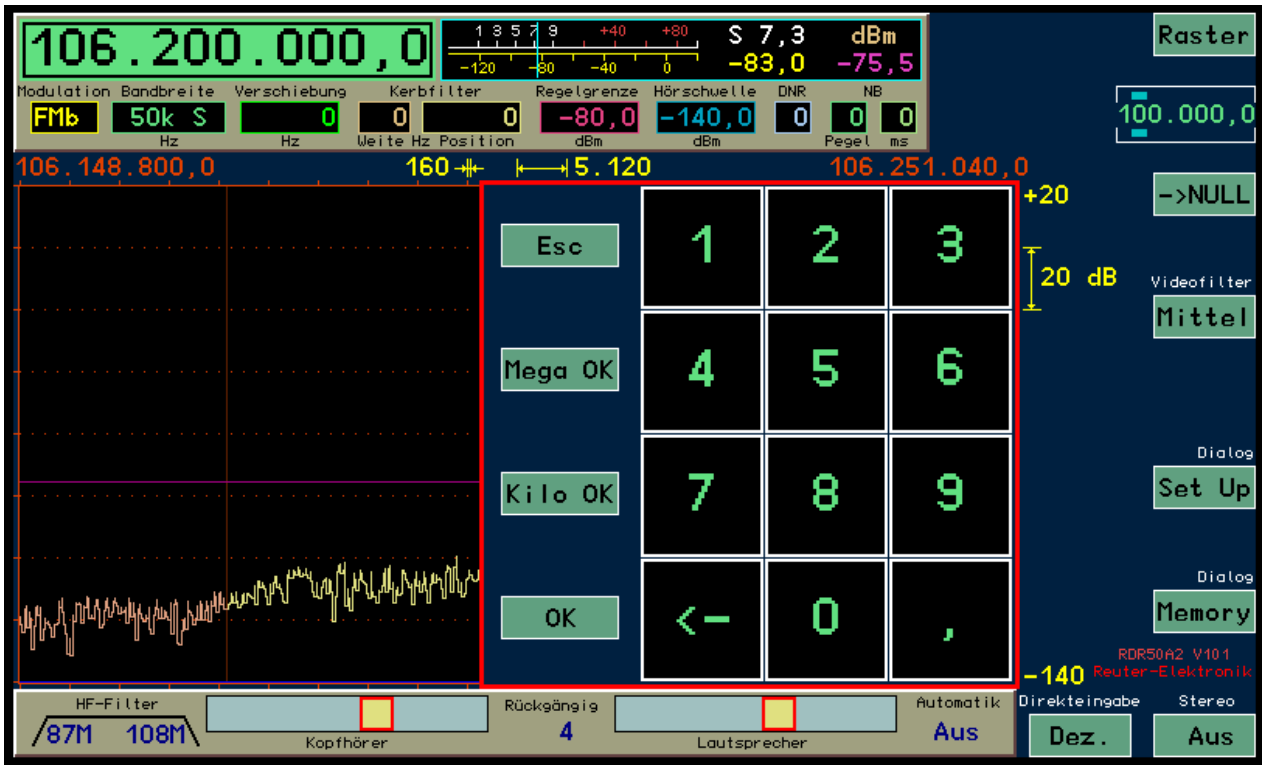
The virtual keys "MHz OK" and "kHz OK" allow you to enter values times the corresponding decimal power. Example:

Input sequence “1” → “0” →,”decimal point”→ “1” → “MHz OK” for direct frequency entry is an acquisition of the frequency 10.1 MHz in the frequency setting (if chosen as active adjustment position!). Too big or to small input values are rounded of to valid values .

Pressing "<-" deletes the last entered digit.

The selection of the active input window (in the picture: “Frequency”) happens by directly touching the desired window (in the RDR54C by turning the knob in the pressed state). Once the cursor has moved to the selected position the value can be changed as usual using the rotary knob or via direct input.

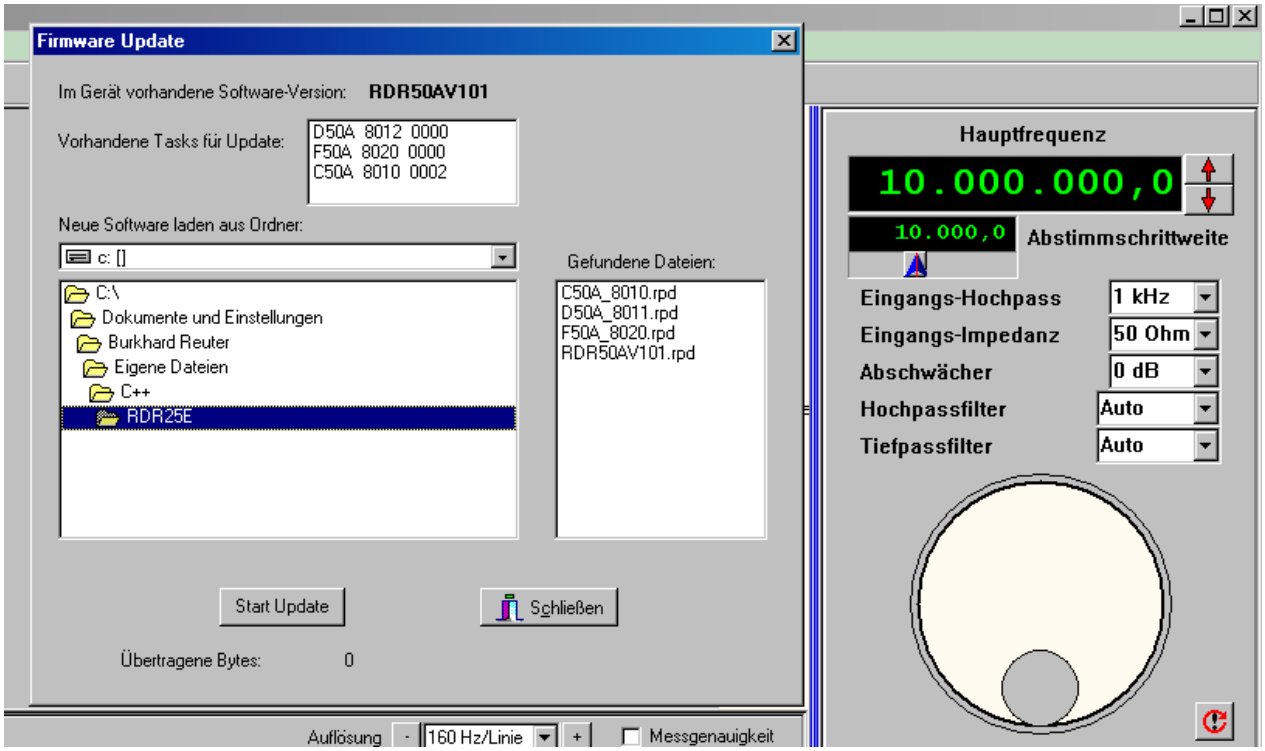
Within the setting mark open dialogues can be shifted also line by line ("scrolled") in order to achieve the desired position. In this case not only the direct number value is touch-sensitive, but the entire corresponding row with the name of the value.



Active decimal direct input window after touching the small “DEC” input field.

14.3 Firmware update

Upgrading the "firmware" of the device is largely automated with the RDR50A. After connecting the receiver to a PC via USB cable use the remote control software "RDR25.EXE”. It is currently in ALPHA status because from all the features only the firmware update is working.



Software to update the firmware in RDR50A

Select the program of the menu item "Settings → Firmware" to open the update program. Make sure that at the bottom right of the program a multiple-digit code number appears which also contains in the characters "D50A". Shown here it would be “RDR50AV101.rpd”. This requires that the USB drivers are correctly installed according to the instructions given in the chapters about the RDR54C.

The RDR50A will be set into a programming state when the firmware update is started. On its display, the boot loader appears and lists the included software versions. This list is then transmitted to the appropriate listing of the update program.

Select a folder on your PC which contains the firmware for the RDR50A. The files always have the extension ". RPD". Files of the .rpd type are displayed.

Start the upgrade process by pressing the button "Start Update". All the files found in the RDR50A are transferred and programmed. Before that the old firmware of the device will be erased. You will see several indications that files are copied / erased in both the bootloader and also the receiver.

Depending of the kind of data, two different ways for the end of the update process can happen:

- The RDR50A automatically starts the new software and is ready for use immediately. Close the programming software and the transfer program RDR25E.EXE.

- A splash-screen will appear asking you to close the program and shut the RDR50A down and then “on” again.

In order to verify the software update, check the user interface of the device and that the new software version is working.

In case of errors occur during the transfer process, the program must be completely closed and restarted. After that the update can be repeated. Also note the following:

- All files which are found will be loaded. In case you want to disable the transfer of individual components (files), remove the files from the selected folder.

- If no file named *RDR50A.rpd is present (main component of the firmware), the device cannot start. The Bootloader will always be active however.

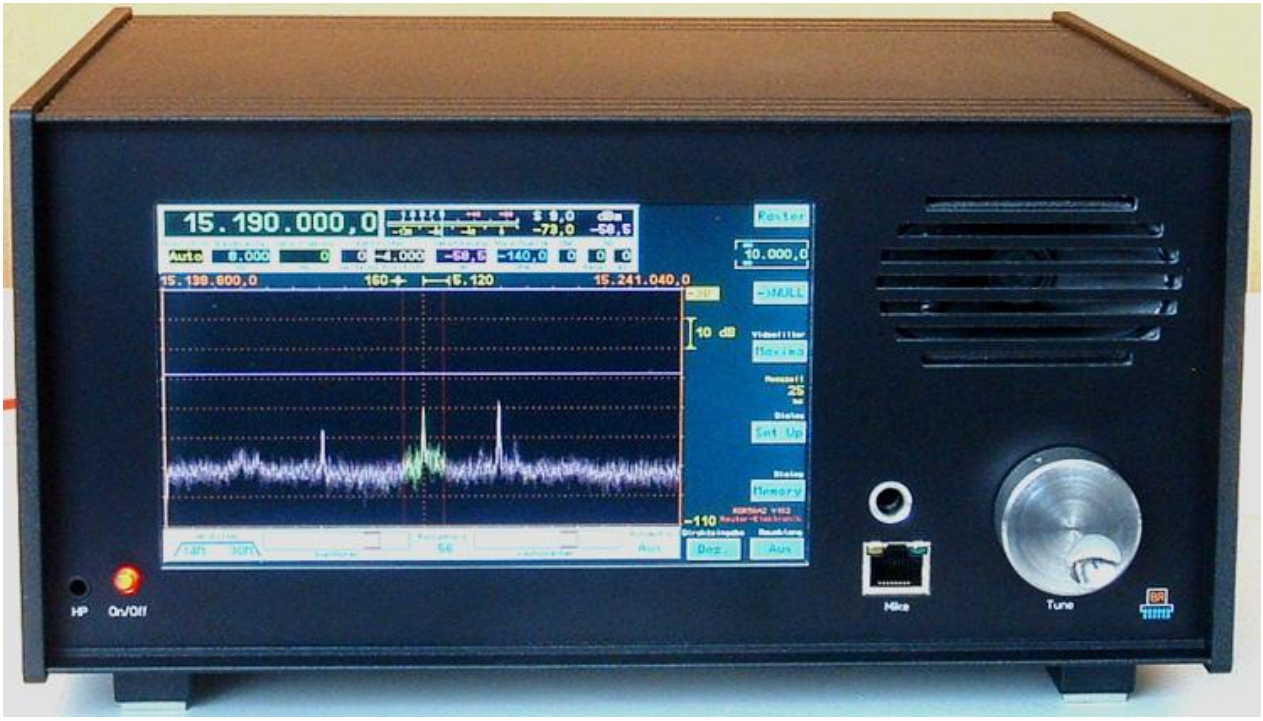
- All components must match (depending on firmware version there are not always new files for all components required). Follow the instructions of the supplied files and the need to use the correct software version. Usually only the main component is reloaded, occasionally, one or the other components needed to be renewed.

- In case of components that do not match, the RDR50A will attempted three times to start up and will then return to the boot loader.

- There are coded (numbered) components for the RDR50A that can only be loaded into a device with the same serial number (purchased software). Never download coded components in a device with mismatching serial numbers. The device will then not boot!

- A dedicated start of the bootloader through the dialogue "Memory" is not possible in the RDR50A. The firmware update software on a connected PC must always be used.

14.4 Revision B



RDR50B2

RDR50 Version B (software V104) is essentially a version A type. There are the following differences:

- In the "setup" dialogue an attenuator of about -9 dB (all frequencies) and a preamplifier with approximately +9 dB (up to 54 MHz, it is always present in any case with at least +17 dB) can be chosen for the RDR50B. The actual frequency-dependent values are calibrated by software and are automatically taken into account with the measurement values (spectral lines, S-meter and power meter) . The switching of the attenuators and the preamp will therefore not change the display values (within the basic accuracy of ± 3 dB)!

Note! The audible and visual signal will not be influenced by the amplification or attenuation of the signal.
Only the sensitivity and the distortion of the receiver will change. Differences will be only audible in case the signal together with the external noise is at the level of the intrinsic receiver noise or in case of intermodulation interferences.

- At the front of the RDR50, the 6.35 mm jack can be used as additional headphone jack (3.5 mm parallel to the socket next to the power switch) as well as a microphone input (unbalanced or balanced). Switching is done via dialogue "Microphone", select "Input". An additional "+ P" (for "Phone") behind the display indicates the balanced or unbalanced connection of the connector as a microphone port. Standard setting is the headphone jack.

Note! Devices without transmitter (B1 and B2) do not feature the microphone dialogue. Here the default setting is always the use of an additional headphone jack. This setting cannot be changed.

- The front-panel RJ-45 connector pin assignment corresponds to that of the Japanese standard. Thus Kenwood microphones can be directly connected, the pin layout can be found in Section 11.5. **Pin 1 of the socket is left!**

Attention! In the "Microphone" dialogue, the auxiliary voltage +5 V has to be switched to the right connection! In conventional Kenwood microphones this is pin 2.

Rear view RDR50B4

(The diagram shown is only one side of the whole circuit of the RDR50 consisting of the 12 pages. In addition there are many pages of the inner circuit of the five built-in programmable FPGA circuits).

Devices RDR50B3 / 4

(the ones with transmitter) are equipped at the rear with an additional RJ-45 jack "CTRL" and two 3.5 mm stereo jacks "PTT" and "KEY". The sockets for PTT and “KEY” have a wiring according to Section 11.5. The active switching signals are always on the left channel (tip) with approximately 3.3 V voltage which must be pulled to ground.

Attention! The right channel of the PTT jack (center / ring) carries the +5 V supply voltage, if it is set in the "microphone" to "Pin 1" otherwise it is at ground potential.

The jack "KEY" is also present in devices without channel (B1 / B2 types of the RDR50). Here it carries the headphone signal. So there are three parallel headphone jacks available in these devices.

The jack "CTRL” carries the BCD code of the switched on shortwave amateur radio band as it is described in Section 11.5. The counting is again "Japanese" as for the front microphone jack, ie pin 1 is left. The assignment is as follows:

- Pin 4 ... 7: BCD code (pin 4 = bit 0, Pin 7 = bit 3) of the currently switched band. 0 = no band (no TX available), 1 = 160 m, 2 = 80 m ... 9 = 10 m band.

- Pin 2: TX-ON signal: active at once with PTT / button inactive after the falling edge of the RF signal.

The BCD signals are positive logic +5 V (1 = enabled, 0 = inactive) with 150 ohm impedance (TTL / +5 V CMOS-compatible). The PTT signal is "open collector" with 50 V voltage and 1 A current capacity and approximately 1 ohm internal resistance to ground when switched on.

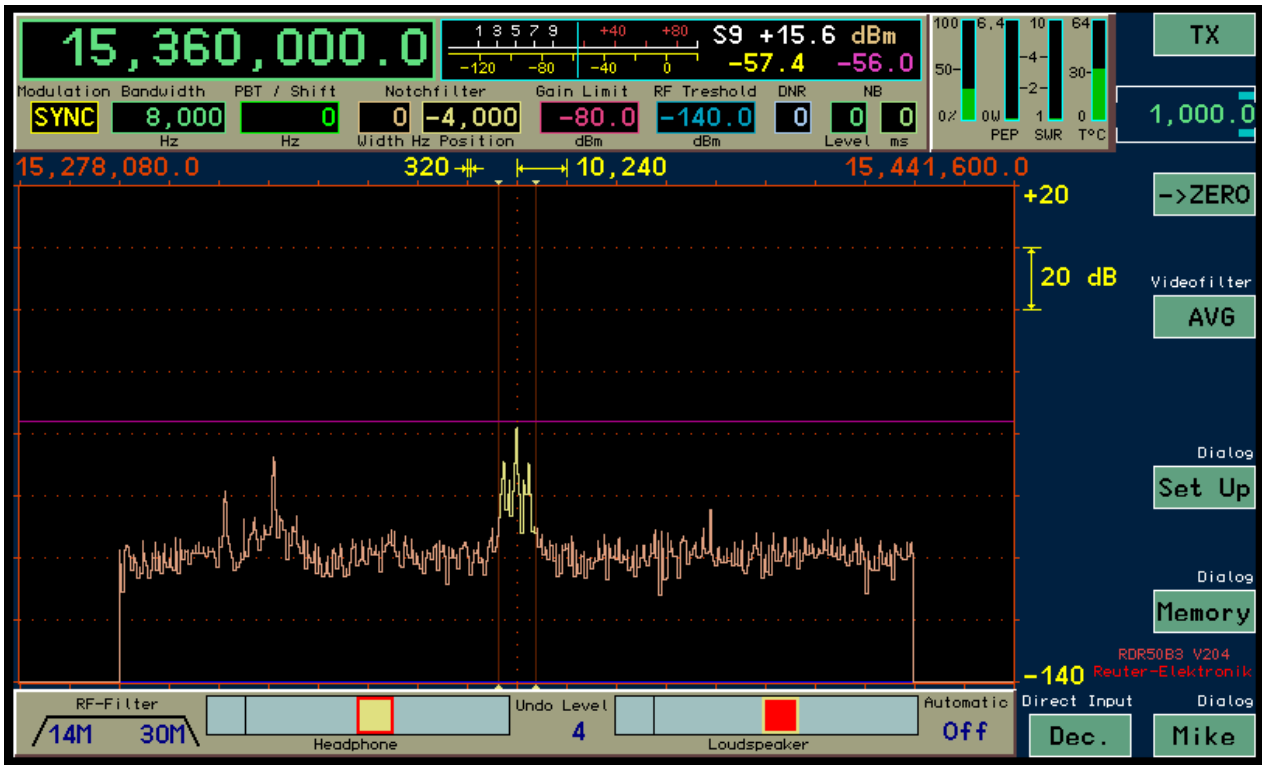
The 3.5 mm jack "S / PDIF" is only enabled for special software (HiFi FM radio). It then carries the digital stereo signal with 48 - 192 kbps and 16 - 24 bit resolution.

14.5 Software enhancements

The touch screen driver of RDR50 was significantly improved. It now allows precise positioning by "pulling" (touch and move sideways on the surface). This works especially well with a soft plastic pen for touch screens.

So now the area of the spectrum diagram for such a "drag operation" is released. Simply use your finger or pen to type on the chart and move the slider to the left or right. The currently active setting will be also changed the same way as if you would turn the rotary encoder on a RDR54.

If the frequency adjustment is active, this function has the following effect: you can “touch” any spectral line (eg, the carrier of an AM radio station) and drag it along in the spectrum window. The content of the yellow line is immediately demodulated. This should include the chosen step size ("grid"). In the often used setting of the spectrum with 160 Hz / 1 kHz, the line is cut in half, at higher resolution in each instance. Then the spectrum moves exactly in the chart, as you would have actually used it and move (it "sticks" to the finger).



The English user interface of the RDR50B

In the set up dialog a new position is available, so the drag function can be changed:

- "Frequency:" As you drag, always adjust the frequency, no matter what kind of input position is currently active.

- "All values :" The current active input position is moved.

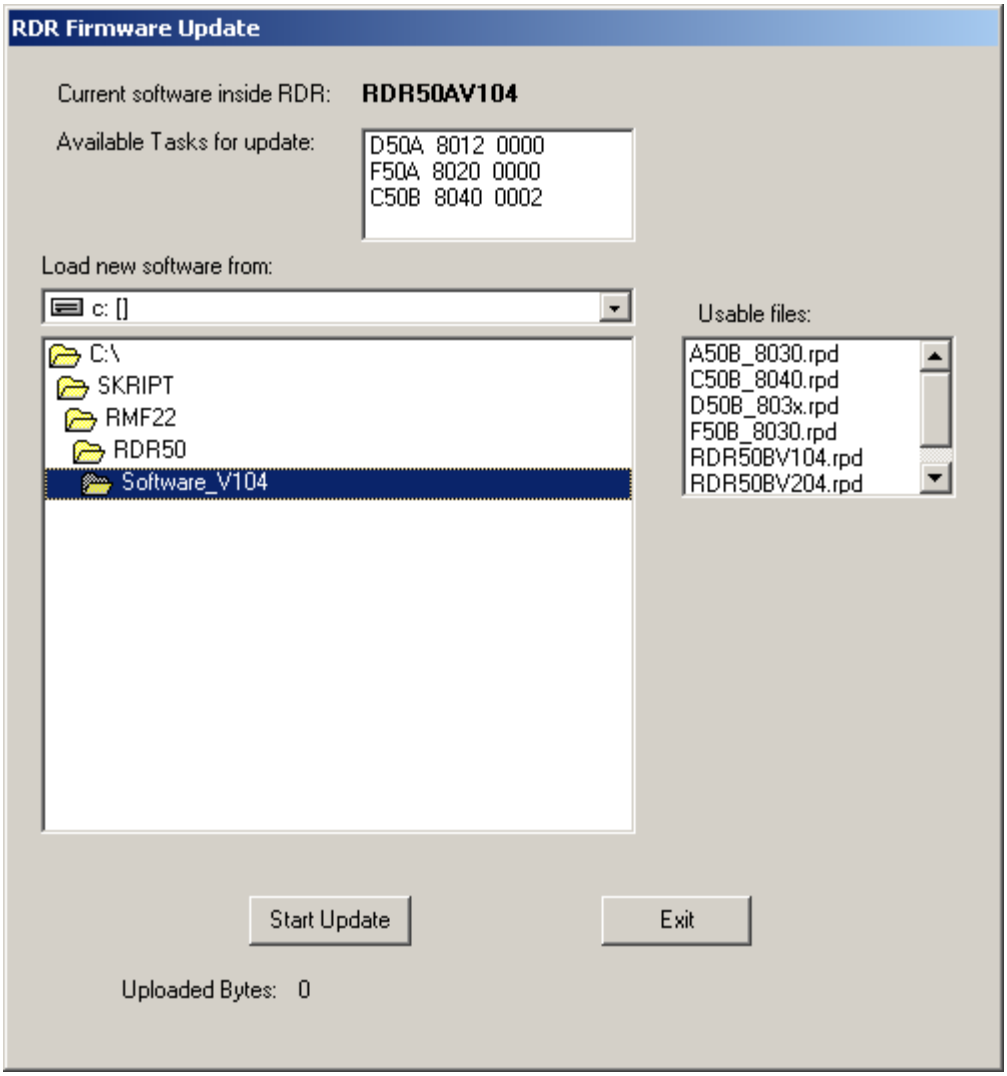
In the former case, one has two settings: As always touch the frequency and by the encoder always the currently active setting position (eg. bandwidth or notch filter). In the second case, one can use the RDR50 without using the encoder.

Other improvements include:

- English-language interface (see above), in addition to the German user interface.
- More sensitive "acceleration function" of the encoder for frequency settings.
- Improving the graphics, such as arrows on the marker lines (in recognition of the listening area Waterfall diagram).
- Finer adjustment of the volume, muting and extra box at the top of the slider.

If a volume control is touched, it is now locked for more than 5 seconds as the active set position (see above, the controller for the speaker). Just like any other position also, eg, frequency or bandwidth. This means that the controller can now be adjusted with the knob. Or by dragging it across the graph (if selected in setup "all values"). If a control setting is not changed for 5 seconds whether by touch or by the encoder, then the active set position jumps back to its original position. Of course, even before any position normally be tapped and activated.

New update program to load software into the RDR50.



The program recognizes a connected RDR50 immediately at start-up (USB drivers must be installed correctly, see Section 7.3) and starts the boot loader in the device. The versions of the currently programmed firmware will be displayed.

A folder on the PC that contains the binary files must be selected prior to the upload. These files always have the extension .RPD. To load the files engage the button "Start Update". All appropriate files are transmitted to the device consecutively.

Attention! Always choose a folder which contains **only the really new files to be loaded**! In case older files (from previous versions before) are present, they must not be loaded into the RDR50.

There will always be only one file with the .rpd extension, such as "RDR50 .... RPD"! This is the complete configuration file of the entire unit. Each configuration existing prior to the update ("Current software inside RDR") is deleted during the update process. If no new configuration file can be found in the selected folder, it cannot be reloaded and the device will not start with the familiar user interface. In this case, repeat the update process and select a valid configuration file.

Vx05:

The software has been enhanced with the version Vx05 by the following features:

- RDS decoder.
- Faster memory access using the dialog for decimal input.
- Stereo width control in 1 % increments from 0 (mono) ... 100 % (stereo) ... 200 % (extra wide).
- Selectable de-emphasis for FM broadcasting radio (Off, 50 microseconds, 75 microseconds).
- Adjustable audio high pass filter 20 Hz ... 300 Hz.
- Adjustable audio low pass filter 0.5 ... 15 kHz.
- Direct selection of the AGC control parameters via touch screen (in the bottom panel of the user interface).

The software has been extended to a variant of the North American continent. The only difference to the English version is the other encoding of the RDS program types. The following versions are available:

V305: German.
V405: English.
V505: English with American RDS decoder.

In the user interface, the AGC control parameters are now available in the lower panel. So they can be quickly selected and changed by touching it. The parameters are stored separately for different demodulators (not for all, FM-W, for example, requires no AGC) and automatically restored when switching the demodulators.

In FM Radio mode, the setting "Width" (usually used for the width of the notch filter) has a different meaning. It then serves to adjust the stereo width. Thus, it can be set from mono (0 %) up to stereo (100 %) and even beyond to double width (200 %). This setting value has a direct effect on the ratio between the sum signal (in the range of 19 kHz at the left of the pilot tone signal) and difference signal (between the pilot tone and the two "RDS humps").

When a station is being received with sufficient strength RDS signal, the RDR50 decodes the signal and displays the program type and channel name on top of the MPX-spectrum (across the frequency readouts). If you tap on one of the texts, an information dialogue opens. It displays the use of RDS data and possibly decoded data errors. If the station transmits radio text, it appears in the dialogue.

The dialogue for entering decimal values was significantly expanded (see below). Now it always shows the first 11 memory locations. When tapping a place name demodulator + frequency) it closes the dialogue and set the device with the data from this place immediately.

If you tap on the "S" in a row, the current setting of the device is immediately written to the position in question and the dialog is closed. There is no further warning or consultation!

By tapping "C" the data memory are deleted and the dialog is closed. Again, without further warning. A deleted space is "free" and a call has no effect, the current setting of the device is not changed.

With these functions, the direct input dialogue allows a very efficient and fast management of the first 11 memory locations. These places can be managed via the Memory dialogue as well as the remaining 52.

Other new features such as audio filters and de-emphasis switching are available in the Setup dialogue and match those of the RDR54 (section 13, page 75) .

Vx06:

The software Vx06 has the following changes :

- S-meter range extended downwards. If the video display is set to less than -140 dBm for the bottom margin, the S-meter measures up to the lower limit of visibility, minimally up to -160 dBm. Even the demodulators can now work as deep as -160 dBm. The demodulation threshold (squelch) can be turned off by set it to the very lowest level (readout "Off").

- Selective filters for AM-H and FM-N. The filter characteristics of the non spectrum-based demodulators AM-H and FM-N were greatly improved. The width is now slightly less than stated in the setting, the slopes are significantly steeper. At 10 KHz bandwidth AM-H (real now about 9 kHz) can suppressed adjacent carriers (5 kHz tones) with about 90 dB.

- Modified AGC for spectrum-based demodulators. The AGC can keep signals over a dynamic range of 140 dB ± 1 dB constant. This way the noise was also highly gained when the control limit was set accordingly low. Now no longer the AGC moves the gain-control deep into the noise. A possible "popping" of the AGC with fast signal jumps out of the noise is greatly reduced.

- Calibration also affects the transmitter. The frequency calibration in memory dialog now affects the TX frequency exactly equal to the RX frequency. One listens and transmitts always at exactly the same frequency (± TX-Shift), regardless of the general quality (accuracy) of the calibration.

Vx07:

The software has been enhanced to version V307 (German) , V407 (English) and V507 (American) for all devices. The following changes are included:

- Improved filters for AM-E and FM-N. The bandwidths were changed slightly and further steepens the flanks.

- Adjustable averaging and additional minimum-hold video filters for the spectrum display.

- Automatic function to return from other set values to frequency adjustment.

Since the complete memory management (except Undo system) is now possible via the direct input dialogue the dedicated items were replaced in the Memory dialogue. They now include an option for the automatic return of a selected set (eg bandwidth or screen resolution) to the frequency. This option can be disabled entirely, will be given out free for the return of HP and LSP (as before), or from any set. The delay time between the last operation of the setting and return to the frequency is adjustable. HP and LSP will always jumped back twice as fast.

- Increased numbers of memory sites to 99. The list in the direct input dialogue can now be scrolled through using the knob ("Revolver principle" forward and backward without stopping at the beginning or end). The dialogue does not close automatically when deleting or saving -> faster operation.

Caution! When a software update is performed sites 1 to 35 getting deleted !

- Adjustable level for the microphone VOX activation and anti-VOX.

The menu item to switch the 5V auxiliary voltage to the microphone input has fallen off. This is no longer necessary because the input is always hardwired for "ICOM - occupancy" at RDR50/54. The vacant item was assigned a setting option for VOX activation threshold.

The threshold can be set as a percentage of full scale. The full scale itself is adjustable with the microphone level setting and is indicated by the modulation bar in the transmitter display panel of the user interface. The VOX activates the transmitter when the modulation bar reaches the set threshold.

When setting the value to "AV" before the level readout an anti-VOX circuit is activated. This always sets the internal threshold to 99 % when a received signal in the demodulation range (yellow spectrum area) reaches the AGC threshold (setting “Gain Limit”). In the case of receiving a stronger signal the VOX is "deaf" and can only be enabled by a very high mic level (full scale modulation). If the signal falls below the AGC gain limit (channel free), the VOX works with the set sensitivity.

Note: By selecting the AGC threshold, ie the point at which regulation begins, the allowable reception level can influence the “deaf“ of the VOX. If one drives the system gain as high as into the noise, the anti-VOX is almost always active. The higher the AGC threshold, the stronger the signals that may be present in the channel without activating the anti-VOX.

The anti-VOX does not respond when the VOX turned on the transmitter. During the transmission period, the VOX tests microphone signals always to the set level. Only when the RDR comes back to reception, the anti-VOX monitors the signals in the receive band again and is able to “deaf” the VOX.

In split mode (TX-Shift in TX dialogue don't equal to 0), the anti-VOX can only monitor signals on the RX frequency. Strong signals on a frequency outside the RX band (on the shifted TX frequency) have no effect on the anti-VOX.

- High-pass filter and equalizer in the microphone channel can be switched off.

The frequency value of the high-pass filter can be set "off". The microphone signal is then passed to the modulator inside the transmitter module without any influence. The bandwidth is about 80 Hz - 10 kHz. The bandwidth of the transmitted signal is then only determined by the transmit filter (setting "Bandwidth Hz"). For all voice modulation types except SSB this filter determines the upper frequency limit.

Caution! In SSB, the position of the filter must be defined relative to the carrier by means of the setting "SSB - Shift" in the Transmitter-dialogue! If the value is set to small, the transmitted signal interferes into the wrong side band due to the finite slope of the filter (150 Hz for 60 dB attenuation)! At least 100 Hz should be chosen as a shift, so that no strong signal is generated in the wrong sideband.

By bridging of the filters, the transmitted AF-bandwidth can be expanded a little to the bottom. The signal then contains quite low frequencies of a broad-band and frequency linear modulation, for example in the AM or FM mode. For normal voice transmission in SSB radio operation, however, the high-pass filter should always be on with at least 140 Hz. The equalizer can then be used to set the frequency response for good speech intelligibility .